Overview of DIGITAL Networking Products

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This document identifies and describes *DIGITAL Networking Products* in terms of function and network configuration possibilities. It also outlines examples of the kind of support that these products provide to user application environments.

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Preface

In planning networking needs, the following questions must be addressed:

1. What functions do you want each of your networked processors to perform?

2. At what location is it best that these functions be performed?

3. What communications techniques are available to link processors performing related work and to support interaction among related groups?

To satisfy the very wide range of requirements that might surface in response to these questions, DIGITAL Networking Products come in many forms. Some support DIGITAL-to-DIGITAL communications, while others enable DIGITAL systems to communicate with nonDIGITAL systems. Some are structured in accordance with the rules specified by the DIGITAL Network Architecture (DNA); some implement rules specified by other vendors.

Two characteristics, however, apply to all DIGITAL Networking Products:

1. Each extends the capabilities of a DIGITAL system in the direction that the user deems best — whether it be functional (resource sharing, communications, distributed processing), dimensional (so as to communicate with nonDIGITAL systems and nonDIGITAL networks) or any functional/dimensional combination.

2. Whether based on DNA or on a foreign vendor's protocols, each implements generally accepted standards. This approach permits communication among a broad range of users. It also preserves design integrity and compatibility over time and through technological evolution.

DIGITAL has developed networking products since 1975. Approximately every two years, a major network program has developed sets of products to serve user needs. Each of these programs represents a Phase in a planned effort devoted to producing new products and capabilities. Because each set of products is fully compatible with those produced in the previous Phase, an orderly network growth pattern is assured. See Appendix B for a brief history of DECnet.

With the addition of DECnet Phase IV products (the current product phase) to the existing set of DIGITAL Networking Products, the degree to which network reach can be extended is increased significantly. A corresponding increase in network penetration makes full network resources more easily accessible to more areas of an existing or planned enterprise. Products such as virtual terminals and personal computers on local area or wide-area networks allow you to put networking capability on every desk that needs it.

By giving you an overview of each DIGITAL networking product, this book can help you determine which ones, alone or in combination, can best support your current and projected needs. If this book doesn't answer all your questions, it may be useful in helping you to frame those to which you need answers in order to approach networking in an organized manner. Could you, for example, benefit now, or should implementation of your future networking plans consider communication over Packet Switching Networks (PSNs)? How do you communicate between a DIGITAL minicomputer and an IBM mainframe on a Remote Job Entry (RJE) Terminal, on a menu/inquiry type basis, or on a task-to-task basis? And suppose that the IBM mainframe is running in a Systems Network Architecture (SNA) environment?

How might you benefit from connecting existing or planned distributed networks to a local area network (lan) configuration? Do you understand how to incorporate a nonDIGITAL system into DIGITAL network? Or are you perhaps looking at a 1,000 node-network and wondering how you can off-load the routing overhead so that each node is free to work a full complement of assigned applications?

These are the kinds of questions this *Overview* will address. Sometimes it may answer them in terms of specific products; at other times it may provide you with the kind of information you need in order to plan an approach to networking.

In addition, this *Overview* will point to other manuals. These references can help you approach any product research effort in an organized manner.

DIGITAL-architected and Other-architected Products

Let us first distinguish between DIGITAL-architected and other-architected products.

DIGITAL Network Architecture (DNA) establishes the rules that are followed in the design and implementation of all DECnet general-purpose and dedicated function communications server products. DECnet products enable any DIGITAL system to participate as a node in a network.

In addition to performing local processing, a general-purpose node can engage in file transfer activities, cooperative processing, and share resources with other DECnet nodes.

DECnet Communications Servers are nodes that perform dedicated network support functions. Some act as terminal concentrators, others off-load routing functions from the applications-oriented nodes, and still others act as Gateways connecting DECnet to PSNs or to IBM SNA networks.

DIGITAL Networking Products that implement nonDIGITAL protocols extend the functional and communications range of both nonDECnet DIGITAL systems and DECnet nodes. These products are, for the most part, protocol emulators that enable, for example, a DECnet node or a nonDECnet DIGITAL system to perform Remote Job Entry (RJE) functions in association with an IBM, CDC, or UNIVAC mainframe. Others enable DIGITAL terminals to appear as members of the IBM family of 3270 terminals, or as HASP workstations to an IBM system. Still others support program-to-program communication between a DIGITAL system and an IBM computer in a network defined by IBM's Systems Network Architecture (SNA).

Why architecture? What good does it do and what do you have to know about it? The rationale for the architected design approach is presented in *DECnet DIGITAL Network Architecture (Phase IV)—General Description*. The structure of DNA and the function of the protocols it defines are summarized in Appendix A of this Overview.

Because the layered structures of the DIGITAL Network Architecture and that of the network architecture specified by the International Standards Organization (ISO) reference model are similar, products based on DNA are well-positioned insofar as future development of an international standard is concerned.

This is important because networks are frequently composed of components made by many vendors. Customers may want to purchase printers from one vendor, personal computers from another, and so on. International standards will make multivendor networks a reality. In tracking the ISO architecture closely, DIGITAL assures that its current and future networking products will implement these standards.

For the moment, however, it may be sufficient to know that an architecture lends stability to a complex set of software/firmware, even through extensions to its capability brought on by technological advance or demonstrated user need.

For example, the Routing Layer of DNA specifies the means by which a message is sent from one DECnet node to another. In early versions of DECnet, messages could be sent only to adjacent nodes. In later versions, messages could be routed to any node in the network along a user-specified path that would be automatically modified to accommodate changes to the network's configuration. Implementation of the X.25 recommendation gave later DECnet nodes the ability to route messages either to DECnet nodes via other DECnet nodes, and to DECnet nodes via a Packet Switching Network (PSN). In DECnet's latest version, nodes can route messages to other DECnet nodes via general-purpose or dedicated router nodes, via PSNs, or via a local area network (LAN) path.

Because of the architectural approach applied in the design of DECnet software, in none of these cases did the added routing capability impact the existing capability. In all cases, functional stability and transparency were retained. As a result, user investment in applications, in hardware, and in software was preserved, even as the new communication services evolved.

How to Use This Book

Chapter 1 identifies DIGITAL networking products and points to a series of application scenarios that describe some user needs with which, based on your own experience, you may be able to identify. The scenarios are presented at the ends of Chapters 3,4,5, and 6.

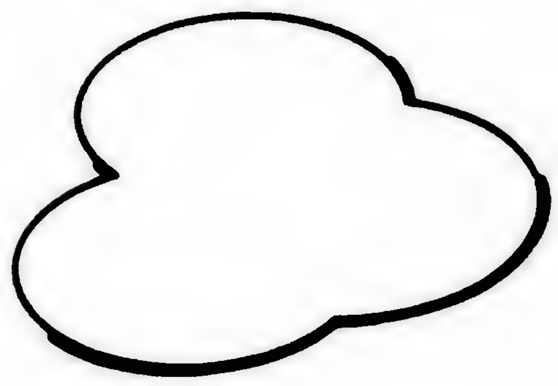
Problems are identified on two levels: communications and application/environment. Although somewhat specific, the application/environment scenarios are meant to serve as examples only. The solutions suggested can just as well be applied in circumstances that model only the general nature of the projected application scenario.

An Index in Chapter 1 identifies the scenarios and tells you where, in the book, you may find each. A Glossary at the end of the book defines many of the technical terms used throughout.

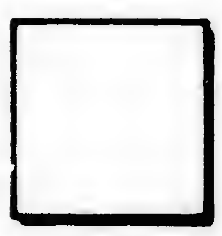
Graphic Conventions

This manual uses the following symbols to identify network and node types.

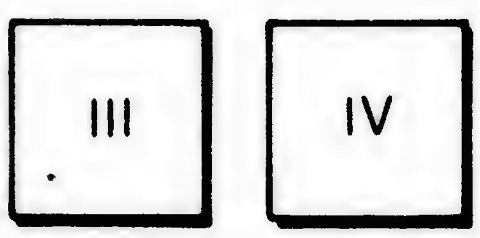
Ethernet (local area network) cable.



A wide-area network. It can be labeled, DECnet, PSN (Packet Switching Network) or SNA (Systems Network Architecture).

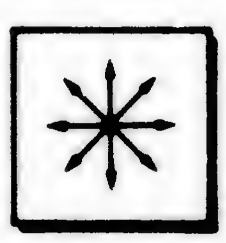


Any general purpose node.

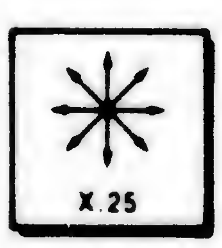


These are used when necessary to distinguish between Phase III and Phase IV DECnet host nodes. A node shown attached to an Ethernet cable is always a Phase IV node.

A nonDECnet node. Can be a DIGITAL or nonDIGITAL system.



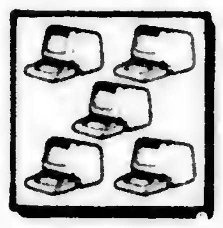
DECnet Router Server.



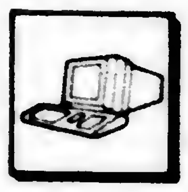
DECnet X.25 Gateway.

(continued on next page)

Graphic Conventions (cont.)

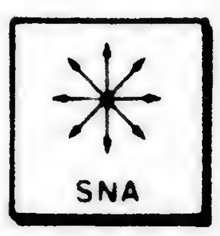


Terminal Server.



PRO/DECnet node.

DECnet SNA Gateway.



DECnet SNA Gateway that connects to an Ethernet.

Chapter 1
DIGITAL Networking Products

DIGITAL Networking Products enable you to build networks that move information to and from terminals, workstations, computers, and storage in a manner best fitted to the needs of the work you have to do and the requirements imposed by your current equipment.

Your work environment may be characterized as a business, a research lab, a manufacturing facility, a government agency, an educational facility — indeed, as any venture in which information is considered an asset that increases in value as it is processed, interpreted, distributed, stored, recalled, and reinterpreted.

The functional needs satisfied by these products are many. You can:

- Access remote files.
- Share resources.
- Make use of distributed data bases.
- Transfer files.
- Give specialized communications capability to DIGITAL systems, enabling them to interact with other-vendor systems.
- Distribute processing.
- Utilize electronic mail, word processors, and enhance other office-oriented applications with communications features that speed the exchange of information among individuals and groups.

The requirements that these products satisfy enable you to circumvent restrictions imposed by equipment limitations and varying communications techniques. By implementing advanced communications concepts and reconciling different communications protocols, DIGITAL Networking Products extend network reach economically. Existing facilities can be retained as selected products provide new and powerful networking capabilities. State of the art products, such as those that incorporate local area network technology, or those that interface with Packet Switching Networks and with environments defined by nonDIGITAL systems, can extend existing facilities significantly.

It should be noted that DIGITAL networking products, as represented by DECnet and the foreign protocol-based products, have seen many years of use at thousands of user locations in a wide variety of application environments. Field experience has demonstrated that these are mature and reliable products. The most recent additions to this product group incorporate the benefits of this extensive experience.

From a structural standpoint, DIGITAL Networking Products can be viewed as belonging to one of two categories:

1. Those based on DIGITAL Network Architecture (DNA).
2. Those based on foreign communications protocol.

Each category is identified in separate sections, following.

1.1 DNA-based Products

These products are built in accordance with specifications defined by the DIGITAL Network Architecture.

DECnet Products. This Overview deals only with Phase III and Phase IV DECnet products. The key features provided by DECnet products include the ability to:

- Transfer files reliably between communicating systems.
- Route messages from a source node to a destination node through other nodes in the network.
- Monitor network operation and change network characteristics, if necessary.
- Adapt data paths to changing network configurations.
- Connect computers in point-to-point and multi-point configurations.
- Communicate with DECnet and nonDECnet nodes over a Packet Switching Network.

Phase IV implementations of DECnet build on proven Phase III capabilities, and are further characterized by the ability to:

- Participate in an Ethernet local area network.
- Build networks consisting of up to 1024 nodes.
- Use the DECnet/SNA Gateway communication server to interact with IBM SNA networks.
- Use the DECnet Router/X.25 Gateway communication server to communicate over Packet Switching Networks.
- Use local area network communications servers to extend networks and application processing capacity cost-effectively.
- Extend networking capability to DIGITAL personal computers.
- Use a network virtual terminal so that a user at a terminal on a local node can log on to a remote node and work as if directly connected to that remote node.

Communications Server Products. These are DECnet nodes that serve specific communications functions only. They do not run applications. Their hardware and software is, therefore, optimized around the specific services they are designed to perform.

- **Router Server.** Performs routing functions for connected network elements. Connects DECnet nodes on a wide-area network with nodes on a local area network. Connects local area networks to one another.
- **Terminal Server.** Gives groups of terminals access to nodes throughout the network.

Gateway Products. These are DECnet nodes that connect a DECnet network with other-vendor networks.

- **SNA Gateway.** Connects DECnet networks to an IBM SNA network.
- **DECnet Router/X.25 Gateway.** Connects DECnet networks to Packet Switching Networks.

PSI Products. Packetnet System Interface products allow DECnet nodes and DIGITAL processors that are not DECnet nodes to connect to a Packet Switching Network utilizing CCITT X.25 protocols.

1.2 Foreign Protocol-based Products

These products provide DIGITAL systems with a communications path to IBM and other foreign vendor systems. They appear to be supported devices to the other vendor's systems. For the most part, these products emulate the IBM Binary Synchronous Communications Protocol (BISYNC), thereby providing a communications facility that links DIGITAL and IBM systems.

2780/3780 Protocol Emulators. These products emulate the BISYNC protocol and enable DIGITAL systems to perform as Remote Job Entry workstations in cooperation with an IBM mainframe. Other products enable similar DIGITAL-CDC, and DIGITAL-UNIVAC communications.

HASP RJE Workstation Emulators. These products enable DIGITAL systems to communicate with IBM systems as HASP workstations.

3271 Protocol Emulators. These products emulate the BISYNC protocol and enable DIGITAL systems to appear to IBM systems as 3271 cluster controllers. Terminals on the DIGITAL system can then communicate with the IBM system over the BISYNC line, and, if required, perform as 3277 Terminals in cooperation with the IBM system.

RSX/SNA Protocol Emulator. This product enables a nonDECnet RSX system to communicate with an IBM mainframe in a network defined by IBM's Systems Network Architecture.

1.3 Index to Application Scenarios

Several network application scenarios are included in Chapters 3,4,5 and 6 of this book. Although some scenarios identify users as having one or more DIGITAL systems, the problems and solutions described can also apply to users who do not currently have such systems.

The following Index may help you identify the application scenarios of most interest to you.

Index to Application Scenarios

Chapter 2
Introduction to DNA-based Products

DNA-based products are structured in accordance with the specifications defined by the DIGITAL Network Architecture. Examination of how Phase IV capabilities were incorporated into the existing architecture can show you why DNA-based products retain their stability, even as they evolve to furnish additional networking services.

2.1 Phase IV Capabilities

The Phase IV architecture enables DIGITAL Networking Products to:

- Participate as components in local area networks.
- Use the special services offered by communications server nodes.
- Use Gateways to X.25 networks.
- Use Gateways to IBM SNA networks.

The following paragraphs and illustrations show how these capabilities can extend network reach.

- Selected DECnet systems can be used to build local area networks. Figure 2-1 shows general-purpose systems networked by means of an Ethernet (local area network) cable.
- Communications server nodes provide special routing and terminal configuration services. Figure 2-2 illustrates how routers extend networks, and how groups of terminals can be connected to the Ethernet.
- DECnet systems can communicate through a Gateway node with DECnet or nonDECnet nodes over Packet Switching Networks. Figure 2-3 illustrates possible connection capabilities from the LAN through the PSN.
- DECnet systems can communicate with a mainframe in a network defined by IBM's Systems Network Architecture through a Gateway node. The Gateway node can be either on or off the LAN cable. Figure 2-4 shows the Gateway off the LAN. Figure 2-5 shows the Gateway connected to the LAN.

The following section will show you how these capabilities were designed into the new set of products without rendering existing DNA-based products incompatible.

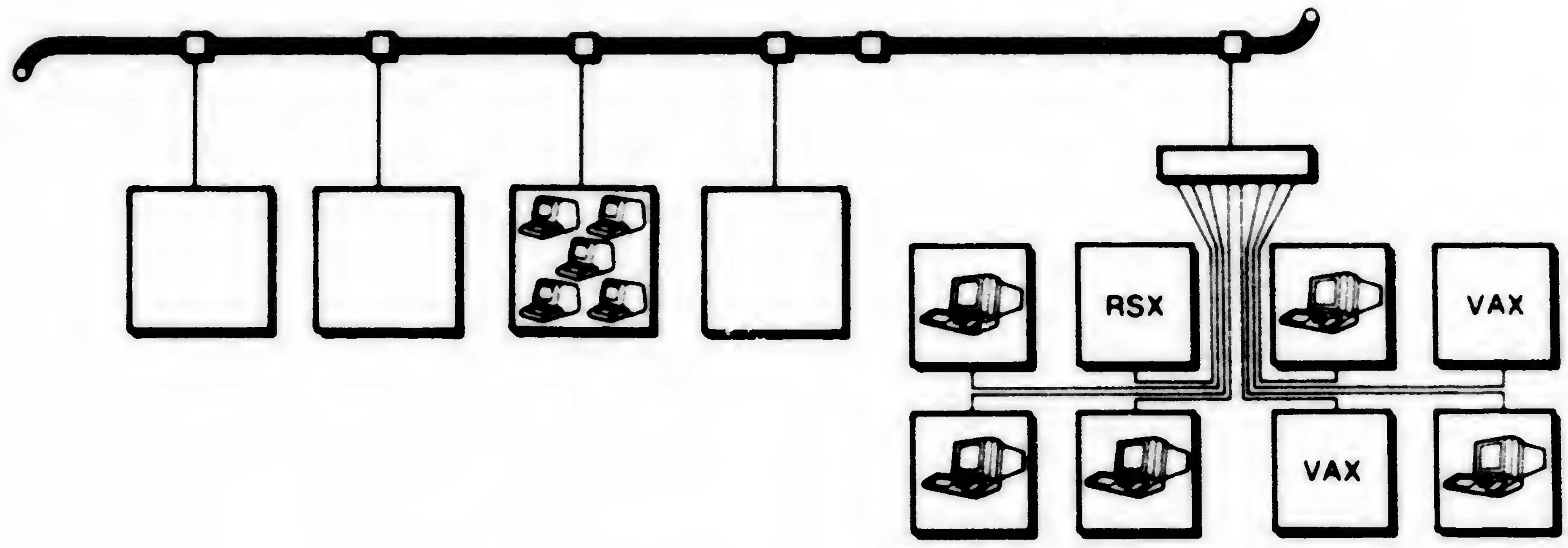


Figure 2-1: DECnet Nodes Networked on a LAN Cable

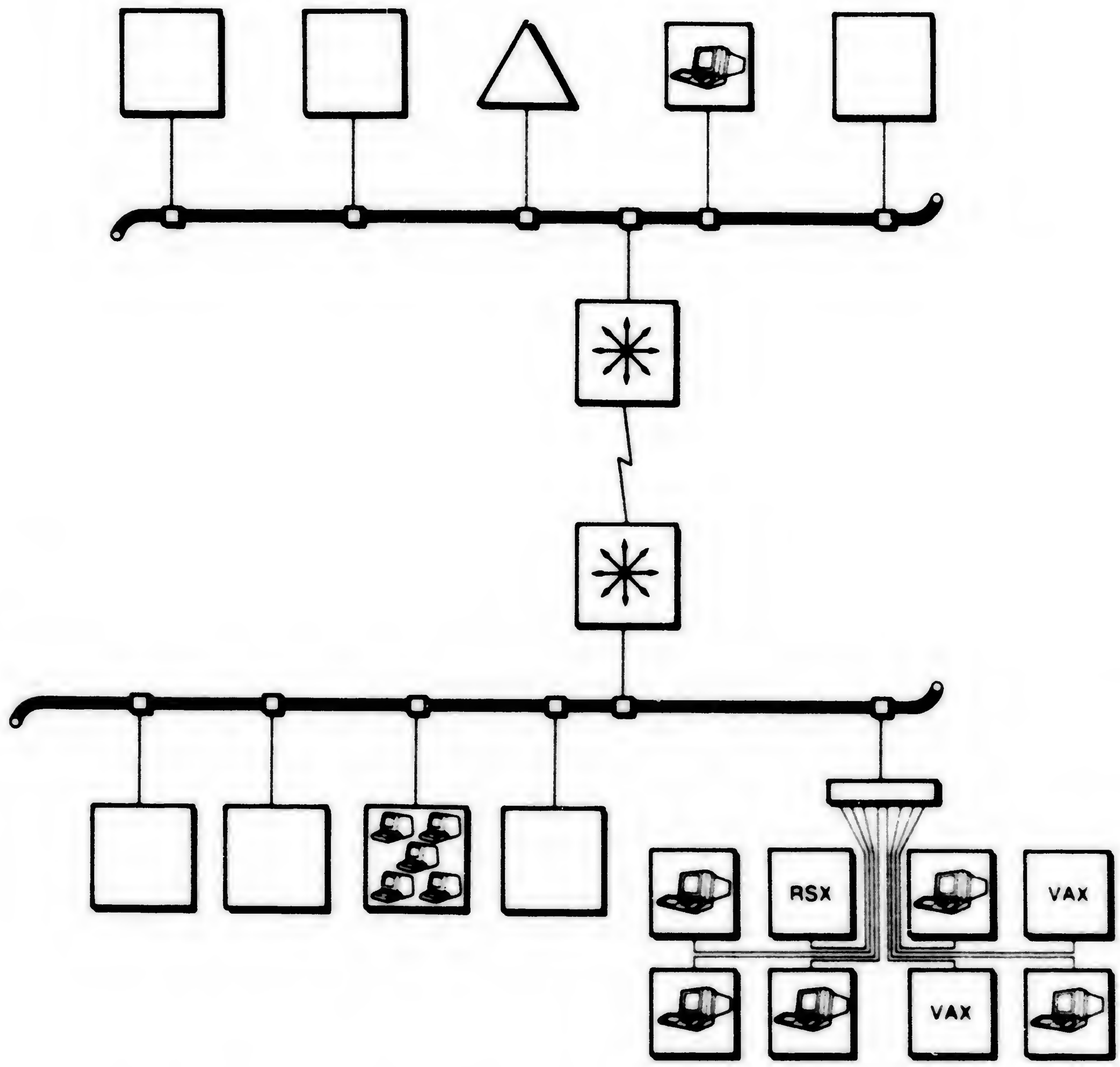


Figure 2-2: DECnet Routers and Terminal Server Incorporated into DECnet Network

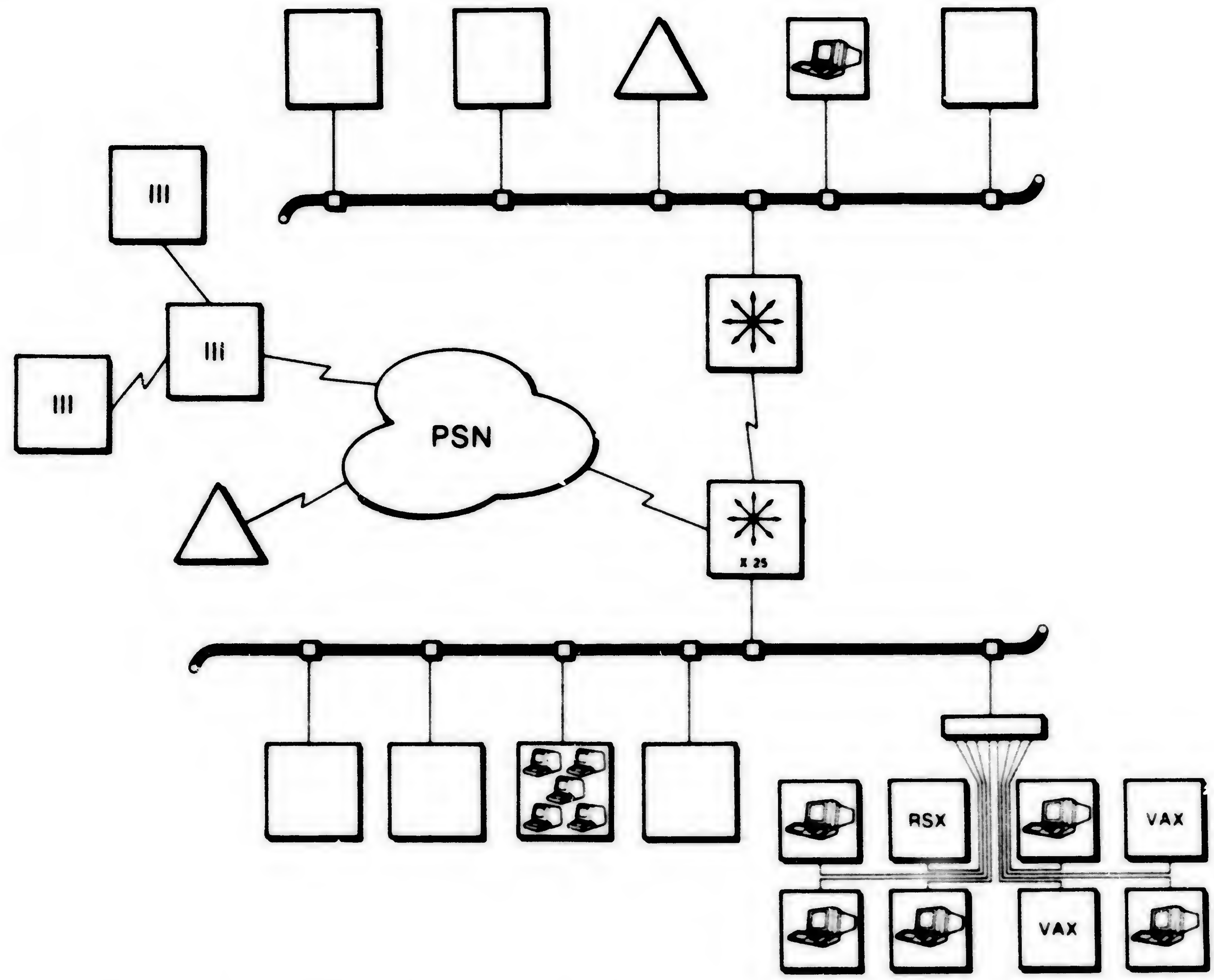


Figure 2–3: DECnet Router/X.25 Gateway Extends DECnet Network

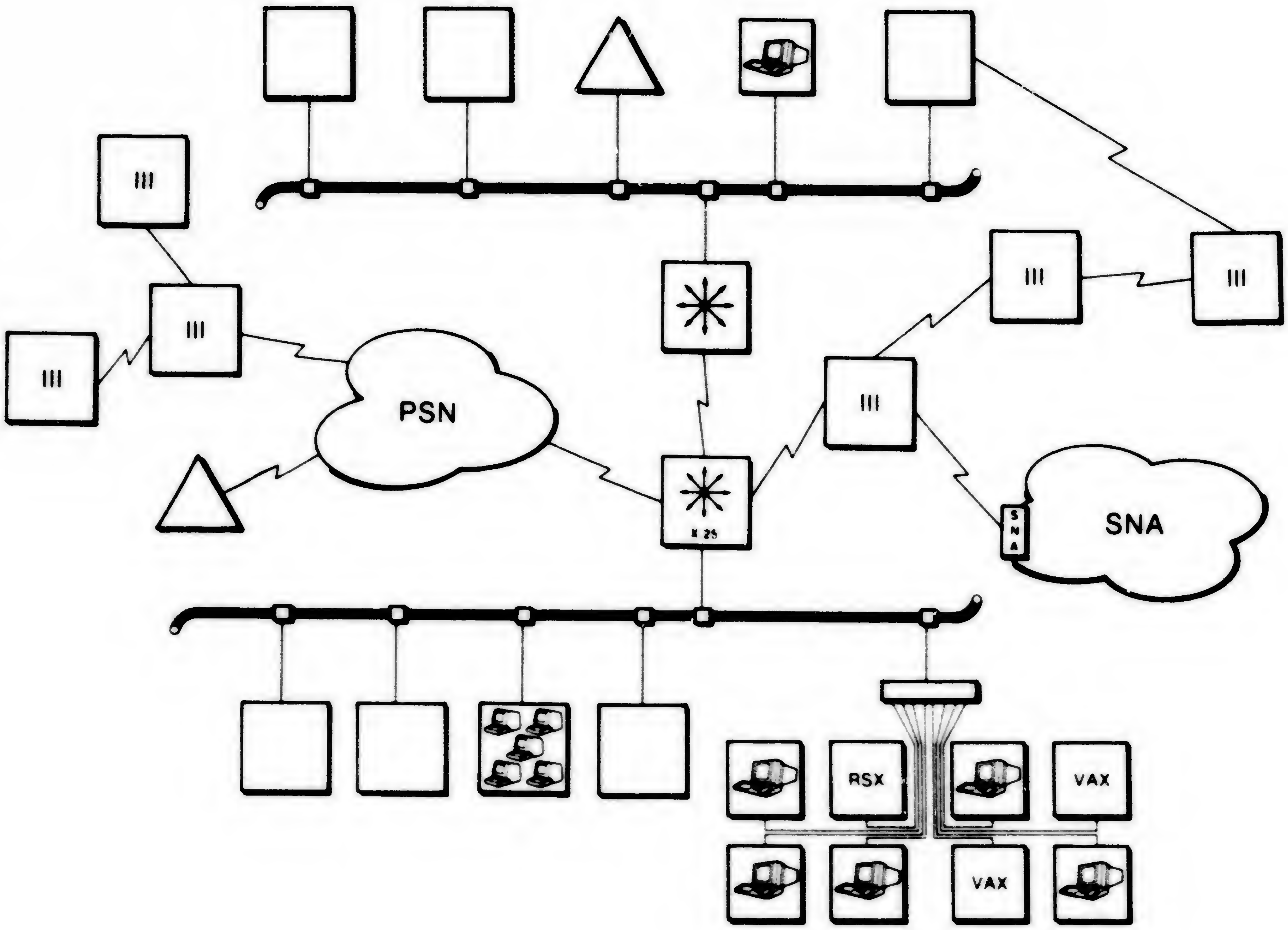


Figure 2–4: DECnet/SNA Gateway off the LAN Cable

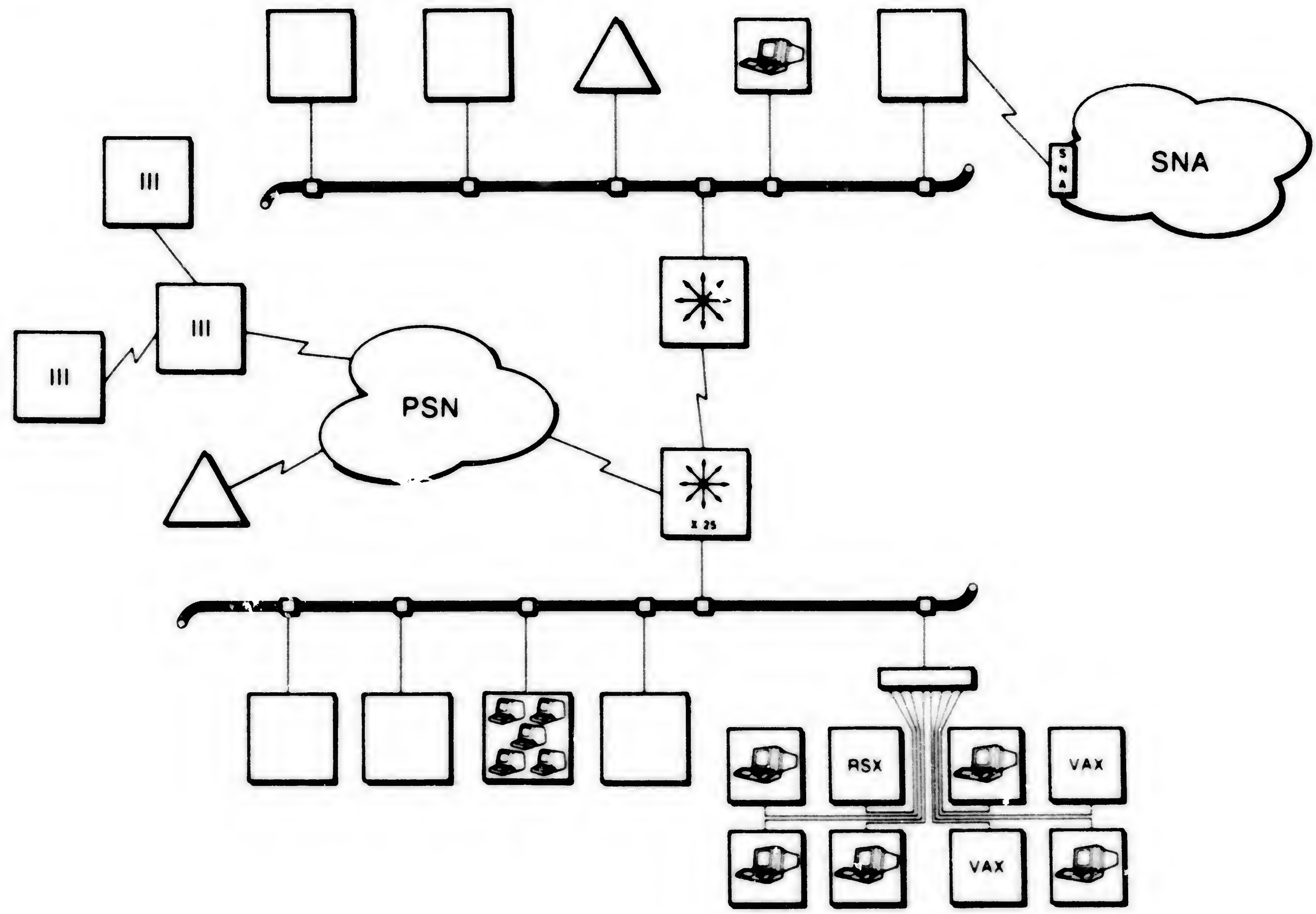


Figure 2-5: DECnet/SNA Gateway on the LAN Cable

2.2 DNA and Product Stability: Some Examples

The DIGITAL Network Architecture specifies a layered structure, as illustrated in Figure 2-6. All DECnet products are implemented in accordance with this structure.

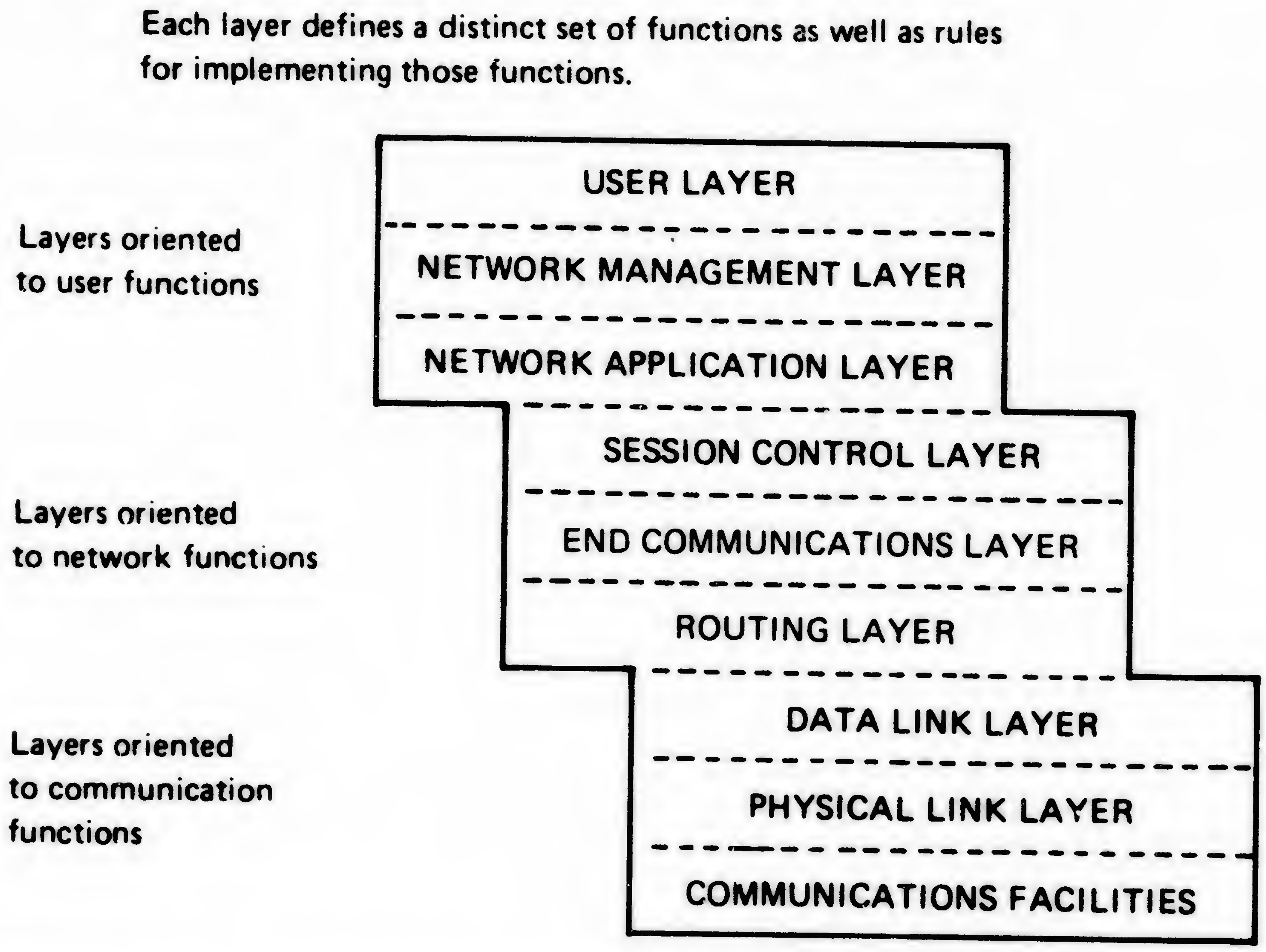


Figure 2–6: The DIGITAL Network Architecture

From a design standpoint, two benefits are derived from this standardized approach:

1. Functions are logically isolated in the design.
2. Interfaces between modules in communicating layers and between protocols in communicating nodes are preserved.

The first benefit assures that any changes are confined to well-defined areas of the design. Also, any problems related to extending the functional capability of the network are resolved in the network rather than in applications. Applications that use those functions are, therefore, not affected.

The second benefit preserves the design structure while permitting change and technological evolution.

From a user's perspective, these two benefits allow new technologies to be incorporated into the network, while protecting investment in existing configurations and in applications software.

The following examples show how these benefits have been applied in some of DIGITAL's most recent networking product offerings.

Building Local Area Networks. The requirements for communicating over the high-speed link that characterizes LANs imposed no need for architectural modification. However, in order to take advantage of the high-speed link, a change was made to the way that routing is handled in the architecture.

Because of this modification, nodes can communicate with one another incurring but a minimum of routing overhead.

Phase IV DNA incorporates and implements the Ethernet local area network protocols. Specifically, DNA (and the DECnet products which implement it) has incorporated the Ethernet protocol, CSMA/CD (see *Carrier-Sense Multiple Access with Collision Detection* in the Glossary). The importance of this protocol is that it has been adopted by many computer and component vendors. The Institute of Electrical and Electronics Engineers (IEEE) 802.3 draft standard, in fact, represents a convergence of Ethernet specifications, ECMA (European Computer Manufacturers Association) documents, and earlier IEEE working drafts. Such general acceptance represents a major step toward standardization of local area, multi-vendor networks. The Ethernet standard, developed jointly by DIGITAL Equipment Corporation, Intel Corporation, and Xerox Corporation is specified in *The Ethernet* (Order No. AA-K759B-TK).

Communications Server Nodes. The DECnet Router Server, which off-loads the routing function from other host nodes, enabling them to devote more of their processing capability to applications, required no change to the architecture. This demonstrates the migration capability of the architecture in permitting new products to be built based on existing design. Both Phase III and Phase IV DECnet products can use the Router Server.

Terminal Server design was accommodated by specification of a new module to reside at the Network Application Layer of the architecture. Since this product provides services not previously available, it can be used only by Phase IV products. Other capabilities furnished by modules at the Network Application Layer are not affected by this additional capability.

Gateway to a PSN. This capability, which extends the reach of DECnet networks economically, was accommodated within the existing structure of the architecture without jeopardizing user investment in hardware, software, or application systems. The DECnet Router/X.25 Gateway enables DECnet nodes to communicate over a PSN either with nonDECnet nodes or with other DECnet nodes.

Design and implementation of the Gateway retains existing DECnet functions and services; no network reconfiguration is required. Network management functions, previously operative in a network consisting of DECnet nodes connected by conventional switched or dedicated lines, were extended to accommodate concepts unique to the X.25 protocol. The fact that a user or a user process communicates with another node over a PSN is completely transparent.

Gateway to SNA. This product extends the reach and functional capability of nodes in a DECnet network. Investment in existing configuration is protected as this Gateway links SNA and DNA defined networks. From an architectural standpoint, the Gateway shows a DNA face to DECnet, and an SNA face to the IBM side. This makes it possible to utilize both SNA and DNA resources from anywhere in the combined network, without modification to components implementing either architecture. This interface can be characterized as a logical extension of SNA into the DNA world. Cooperating application programs communicate with one another through this interface.

Chapters 3 and 4 describe the DNA-based DIGITAL networking products.

Chapter 3
DECnet

These DIGITAL Networking Products consist of software and communications hardware that enable DIGITAL processors to communicate with one another. Functions performed by a stand-alone processor can be distributed over a network. Control over DECnet network operation can be centralized, localized, distributed, or mixed, depending upon user requirements.

With certain DECnet facilities and sets of compatible products enabling DECnet systems to interact with computers made by other vendors, network reach can be significantly extended, while preserving investment in current equipment and applications.

Computer-to-computer communication by means of DECnet can take place over dedicated and switched lines and within wide-area, local-area, and combined wide-area/local-area network configurations. (See Application Scenarios #1 and #2). The choice of computer to use at any particular location in the network depends almost exclusively upon the kinds of applications you want to run at that location.

Choices can be made among any of the members of the 32-bit (VAX-11), 16-bit (PDP-11), or 36-bit (DECSYSTEM-20 and DECsystem-10) computer families of DIGITAL processors to construct networks best suited to your information processing and communications requirements. Further, the user has complete flexibility in the choice of operating systems, as shown below.

- In the 32-bit family of DIGITAL processors, all VAX/VMS systems can serve as network nodes.
- In the 16-bit family, the following systems can serve as network nodes:

  RSX 11M

  RSX 11M-PLUS

  RSX 11S

  RSTS/E

  RT-11
- In the 36-bit family of DIGITAL computers, TOPS-20 and TOPS-10 systems can serve as network nodes.

Since DECnet software enables communication and end-to-end interaction among this broad range of processors, a DECnet network can place a user-specified level of computational power where it is needed. Also, network information flow can be optimized to better serve the structure of the organization. Application Scenario #3 shows you how a DECnet network can make special, non-portable processing capabilities available to remote users.

On functional and communications levels, DECnet nodes enjoy peer relationships. Each can do the same kind of work, support program development, exchange messages, share resources, transfer and receive files, exercise similar network management functions, and engage in program-to-program operations. Terminals in a DECnet network can log on to and act as if they were directly connected to remote nodes in the network.

Some nodes have a greater communications range than others. Some, for example, can be connected to a local area network cable, communicate with other DECnet or nonDECnet nodes over a Packet Switching Network, or communicate with IBM mainframes in configurations defined by IBM's Systems Network Architecture.

Characteristics and features of DECnet are discussed in the following section.

3.1 DECnet: Characteristics and Features

DECnet couples a broad range of functions with a flexible communications capability. File transfer, terminal access to remote nodes, resource sharing, distributed processing, user-to-user communications — all these can take place between local and wide-area networks, and between DECnet and other vendor networks.

Some aspects of DECnet's compatibility and flexibility are briefly discussed in Section 3.1.1.

DECnet features encompass functions related to communications, network management, and user utilities that are integrated into the entire product offering. These features are discussed in Section 3.1.2

3.1.1 Compatibility and Flexibility

DECnet networks are made up of general purpose computers and terminals linked by a common set of communication protocols. Appropriate software is all that is required to extend functional range. If that software happens to be available on a node anywhere in the network, terminals throughout the network can, in many cases, access and use it.

The peer relationship among nodes in a DECnet network permits the same, higher, or lower levels of function to be exercised by specific nodes or groups of nodes. Since a DECnet topology is unconstrained, functions can be centralized or distributed, depending exclusively upon user requirements.

Hierarchical architectures that specify network topologies dominated by a high-end mainframe may not permit such flexibility.

3.1.2 DECnet Features

DECnet features are discussed here in terms of functional and communications capabilities.

3.1.2.1 Functional Features — DECnet's functional features center on activities normally performed by:

- The system or network manager
- The terminal user
- The programmer
- The user of a networked PRO/DECnet personal computer

Features that support each of these user functions are identified in the following.

System or Network Managers. Because DIGITAL networking product design recognizes the need for networking control tools, DECnet network management enables the system or network manager of most DECnet nodes to:

- Give networking capabilities to a local DIGITAL system by installation of DECnet software.
- Give networking capabilities to a remote DIGITAL system by down-line loading DECnet software from an existing node.
- Monitor network operation by displaying status, error, and performance statistics for individual or groups of network components.
- Display messages concerning significant events experienced by the network.
- Test local and remote network components to determine whether messages are properly transmitted and received.
- Analyze network information from memory readouts issued by failed nodes.
- Down-line load programs to remote nodes.
- Modify node characteristics and network configuration.
- Fine-tune node performance.
- Specify special node names and access control information for users of local systems.

Terminal Users. DECnet features available to the terminal user include the ability to:

- Log on to a remote node and use resources located there.
- Engage in dialog with users at other terminals, either at the same or at a remote node.
- Transfer files.
- Display information relative to specified network components. While primarily a system management feature, this capability is useful to a terminal user who may want to determine the state of a node or a line before initiating an interactive procedure.

Programmers. DECnet features available to the programmer include the ability to:

- Write programs that use DECnet file and record access facilities to:
  1. Open or create a file.
  2. Read and write records to a local or remote file.
  3. Append records to a local or remote file.
  4. Close, purge, or delete a local or remote file.
- Use a broad range of programming languages.

PRO/DECnet. Features available to the user of a PRO/DECnet node are outlined in Section 3.2.5.

3.1.2.2 Communications Features — DECnet's communications features permit DECnet-DECnet as well as DECnet-nonDECnet interaction.

Interaction between DECnet nodes can use the entire range of facilities offered by the DIGITAL Network Architecture, as outlined in Appendix A of this manual. If, however, for a specific set of cooperating applications, running in different nodes, you want to use nonDECnet protocols, you can employ the means noted below for interaction between DECnet and nonDECnet systems.

Interaction between DECnet and nonDECnet nodes uses only the communications capabilities residing in the Physical Link and Data Link Layers of the architecture (see Appendix A). This level of interaction will enable you to send to or receive from a nonDECnet system. Any processing that takes place prior to transmission or upon reception must be managed by the user application.

The routing and Gateway capabilities, outlined below, are significant communications features of DECnet.

Message Routing. In terms of its ability to route messages, a DECnet node can be either a route-through node, an end-node, or a dedicated routing node (Router Server).

- A route-through node acts as an originating point, a terminating point, and a transit point for data flow. It can receive a message from an adjacent node and send it to another adjacent node which may be either its final destination or the next route-through node on the path to the message's final destination.

  Figure 3-1 shows a DECnet network composed of route-through nodes. These can be either Phase III, Phase IV, or mixed. In this configuration, node A wants to send a message to node D. The preferred path, specified by the network manager is A-B-C-D. Normally, the message destined for node D is passed on by the route-through nodes until it reaches its destination. If, however, line B-C, or node C itself, becomes unavailable, the message is automatically dispatched by the routing mechanism to node F for transmission to node D along the most acceptable path emanating from node F. This capability is known as *adaptive routing*.

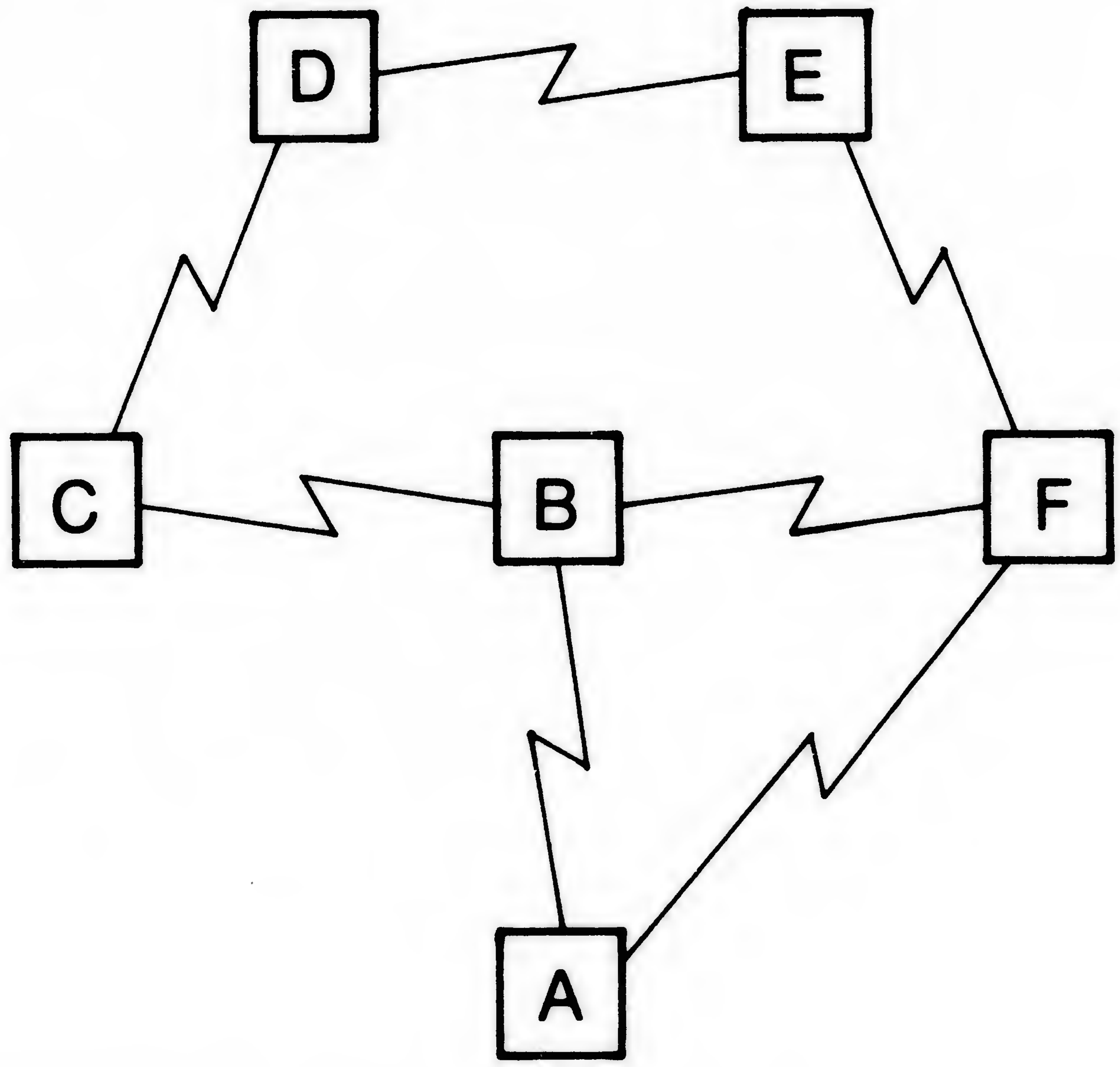


Figure 3–1: Adaptive Routing

- An end-node can send messages to, or receive messages from, any node in the network. However, it has no route-through capability. Transmission from or reception to a Phase III end-node uses the route-through capability of an adjacent node. End-nodes in a Phase IV LAN configuration transmit and receive over the cable. These nodes can use a Router Server or a route-through node on the LAN to communicate with nodes indirectly attached to the LAN.

  In DECnet Phase IV, VAX and RSX nodes can be configured either as end nodes or route-through nodes. As end-nodes attached to a LAN cable, they can send and receive to any other nodes on the LAN by means of the cable, and send to/receive from any nodes off the LAN by means of the Router Server or host routing node. This capability is described more fully in Chapter 4.

- The DECnet Router Server is a DECnet Communications Server devoted to the routing capability. It cannot process applications.

  Use of the Router Server node enables routing functions to be off-loaded from the host nodes, thus permitting a greater percentage of memory and computer cycles to be devoted to applications processing or other functions.

When configured as route-through nodes in a Phase IV configuration, VAX and RSX nodes can send to and receive from other nodes off the LAN without the benefit of the dedicated router. Choice of configuration (end-node or route-through node) is exclusively user determined.

In Figure 3-2, Phase IV end-nodes using the dedicated router are labeled, and a Phase IV route-through host exercising resident routing functions is shown. Note that Phase III and Phase IV route-through and end-nodes can send to and receive from nodes on the LAN cable by means of the DECnet Router Server.

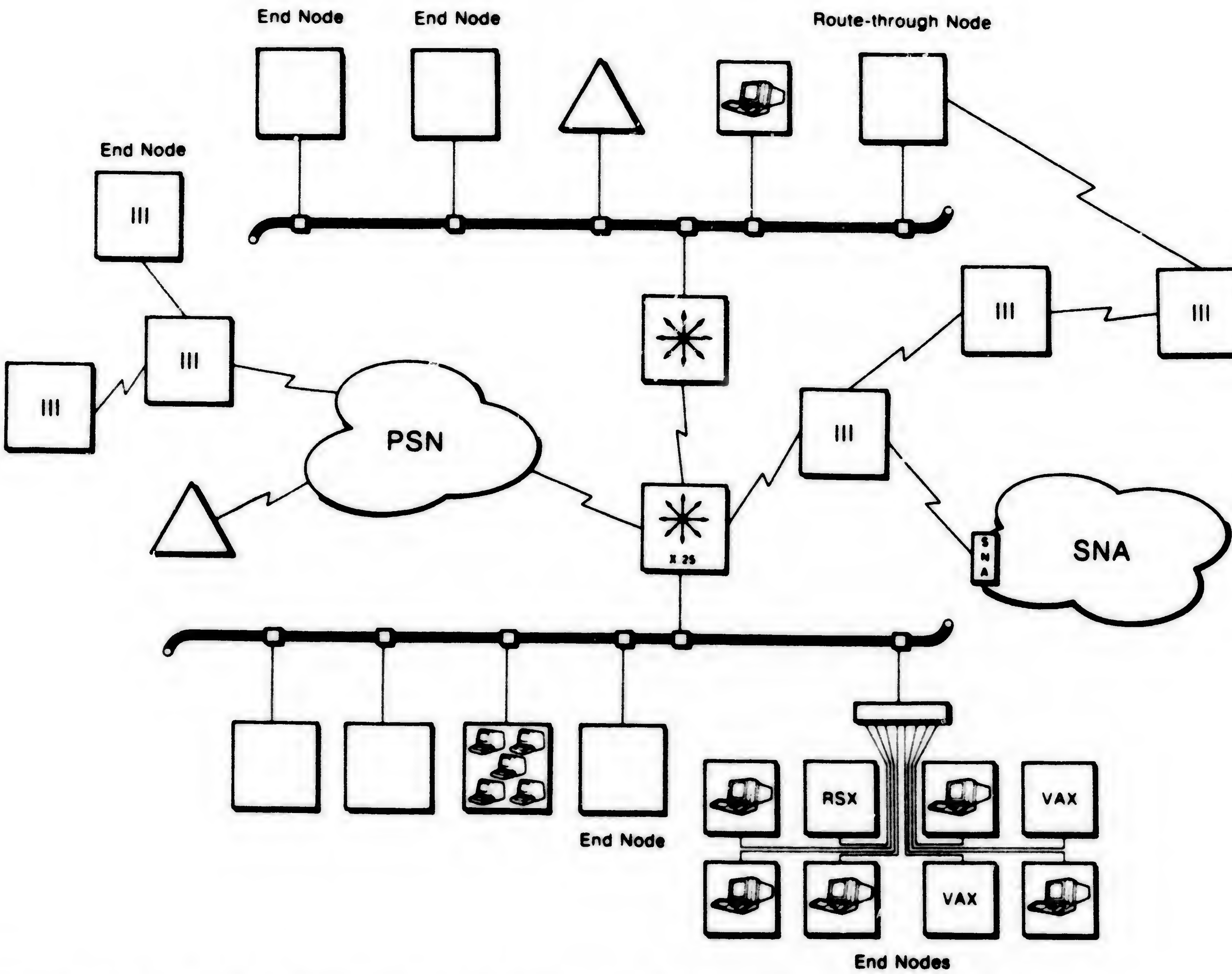


Figure 3–2: Route-Through and End-Nodes Can Use the Router Server

Gateway Nodes. Gateway nodes connect Phase III and IV nodes with Packet Switching Networks and with IBM SNA networks. See Figure 3-3. Nodes that interact with a system beyond the Gateway node must run Gateway Access Software. Chapter 4 discusses Gateway nodes in greater detail.

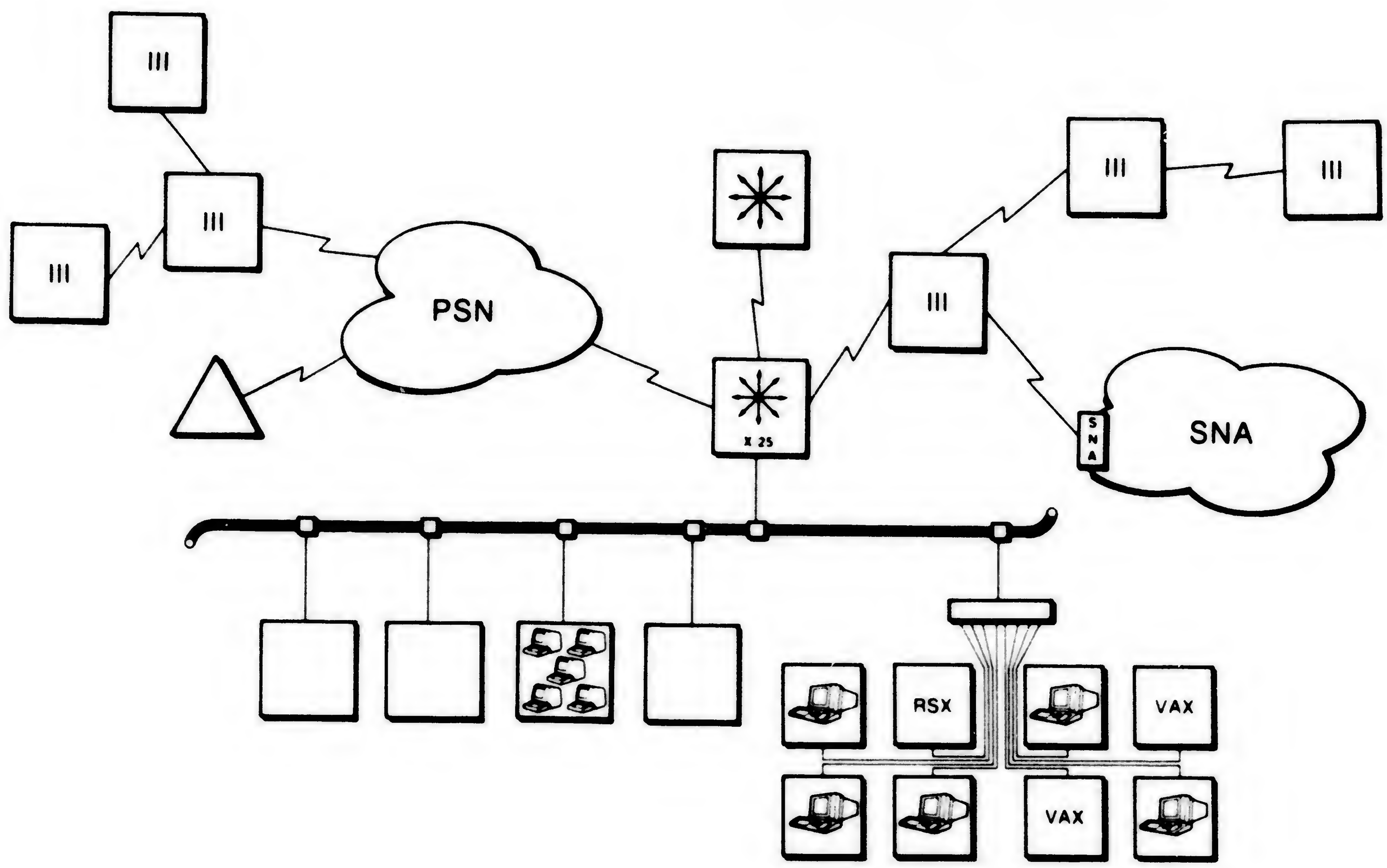


Figure 3–3: Nodes Use Gateways to Connect with PSN and SNA Networks

3.2 Phase IV Introduces New Capabilities

Phase IV of DECnet implements a network architecture that supports proven and market-accepted communications technologies. These features provide for a greater degree of flexibility in designing network configurations. They also offer further assurance of communications protocol compatibility over time between both DECnet-DECnet and DECnet-nonDECnet network configurations.

Other new capabilities available in Phase IV DECnet include use of the previously identified dedicated function nodes, such as Routers, Terminal Servers, X.25 Gateways, SNA Gateways, and networked personal computers.

3.2.1 Link-independent Network Architecture

This means that anything directly or indirectly connected to the LAN cable can communicate with anything else directly or indirectly connected to it. This includes DIGITAL Phase III and Phase IV nodes, nonDIGITAL nodes, nonDECnet nodes, and nonDIGITAL networks (PSN and SNA). Figure 3-4 summarizes the kinds of equipment that can be linked by means of this structure. The subsequent figures and related text illustrate the connections and identify the market-accepted communications technologies used in implementing them.

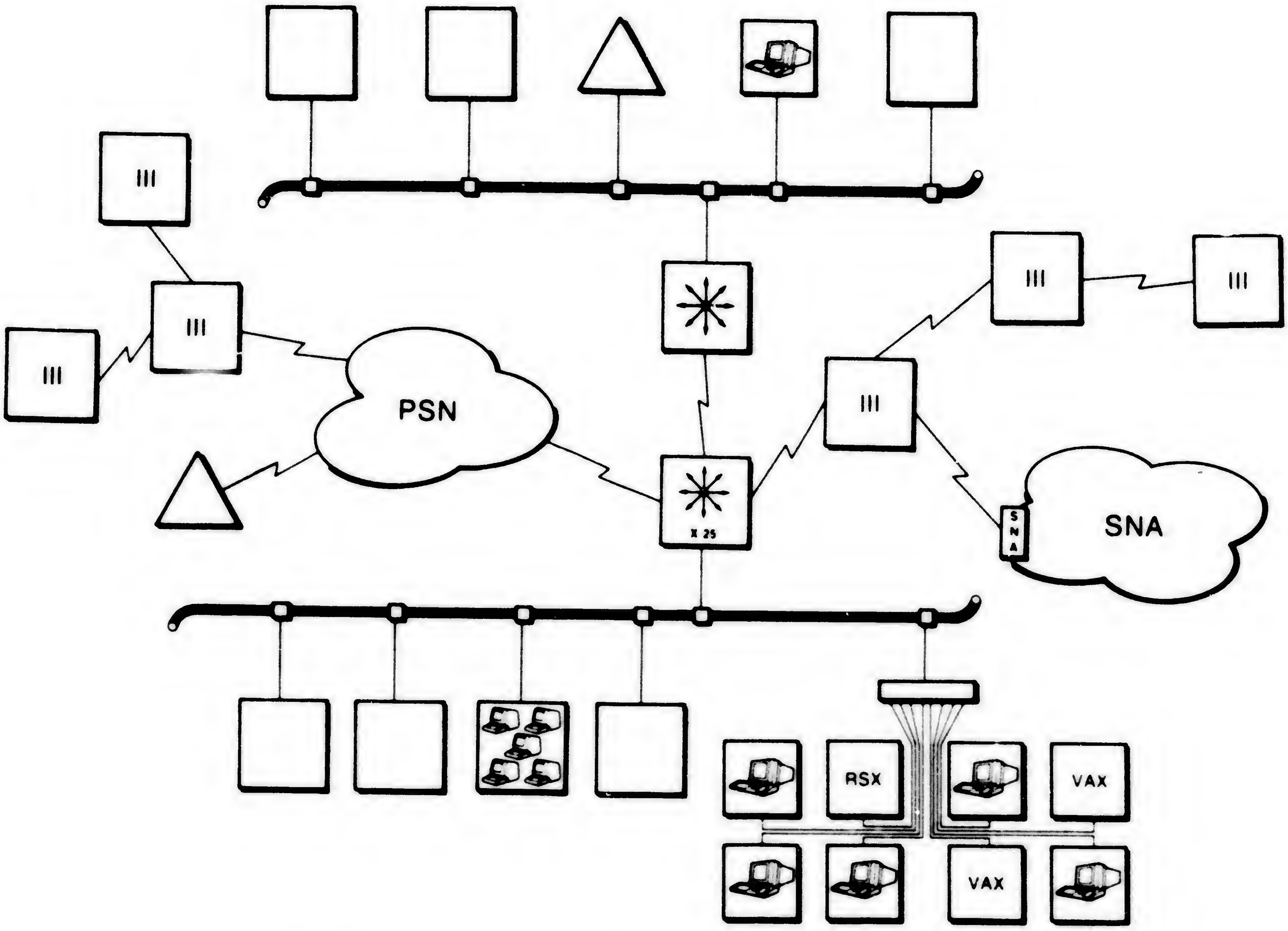


Figure 3-4: Full Range of Connectable Nodes

All connections to the LAN cable (Figure 3-5) use the hardware listed in Section 3.2.2 and implement the Ethernet communications protocol.

The dedicated Routers (Figure 3-6) are DECnet nodes. They communicate with other DECnet nodes by means of DNA protocols.

Protocols based on the CCITT X.25 recommendation handle communication between DECnet nodes and DECnet or nonDECnet nodes attached to a PSN. See Figure 3-7. DECnet-nonDECnet communications use X.25 Gateway functions resident in the Gateway; DECnet-DECnet communications use protocols specified by the DIGITAL Network Architecture.

The SNA Gateways (Figure 3-8) transmit DNA and SNA protocols in effecting communication between DECnet-VAX nodes, and an IBM configuration defined by the Systems Network Architecture.

DECnet nodes can interact with one another on an end-to-end basis; non-DECnet systems and DECnet nodes are compatible on the communications level (as implemented in the Physical Link and Data Link Layers of the architecture).

End-to-End interaction between DECnet and nonDECnet systems on the LAN must be implemented by the user. Such implementation will concern the architectural layers above the Data Link Layer.

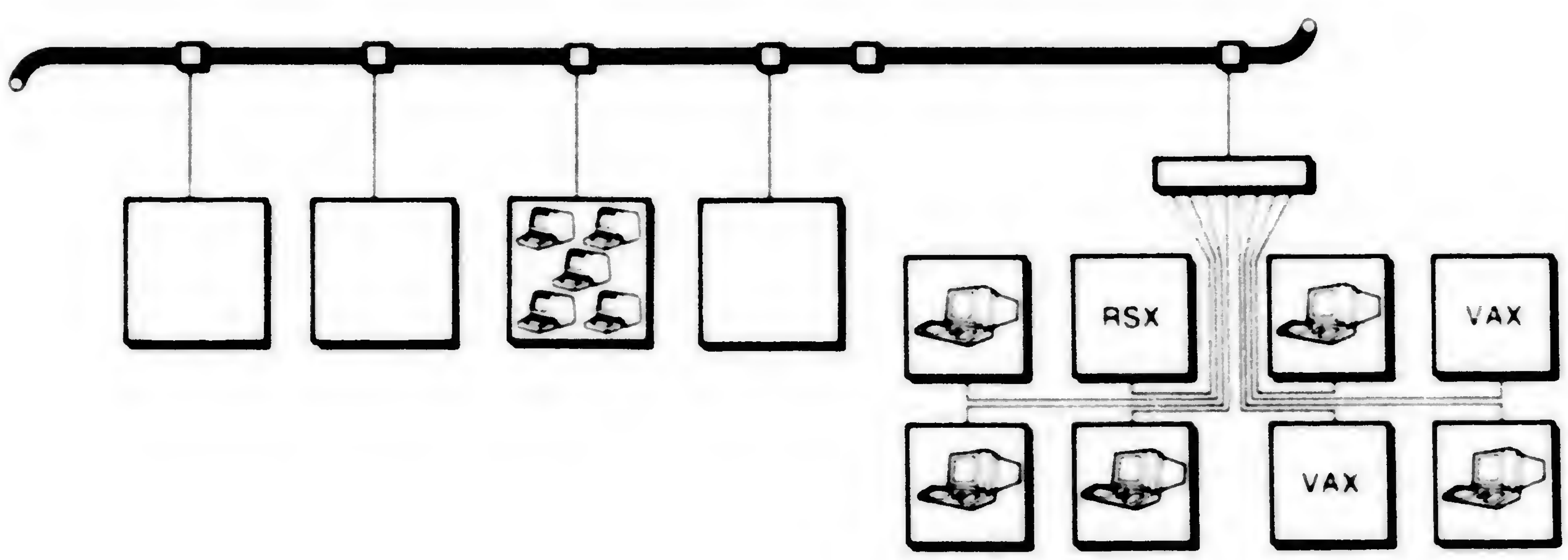


Figure 3–5: Connections to LAN Cable

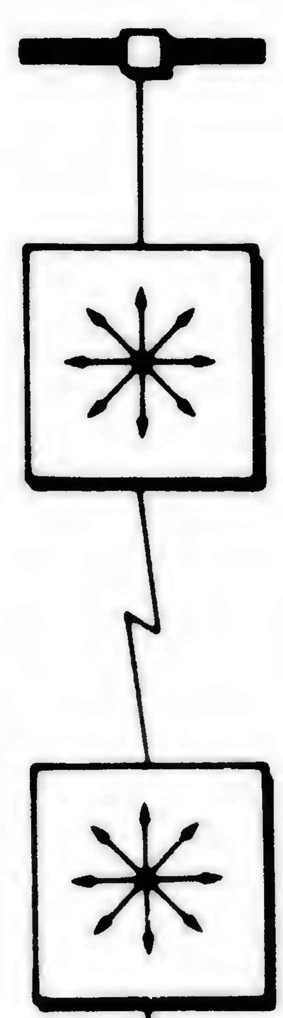


Figure 3–6: Connected DECnet Router Nodes

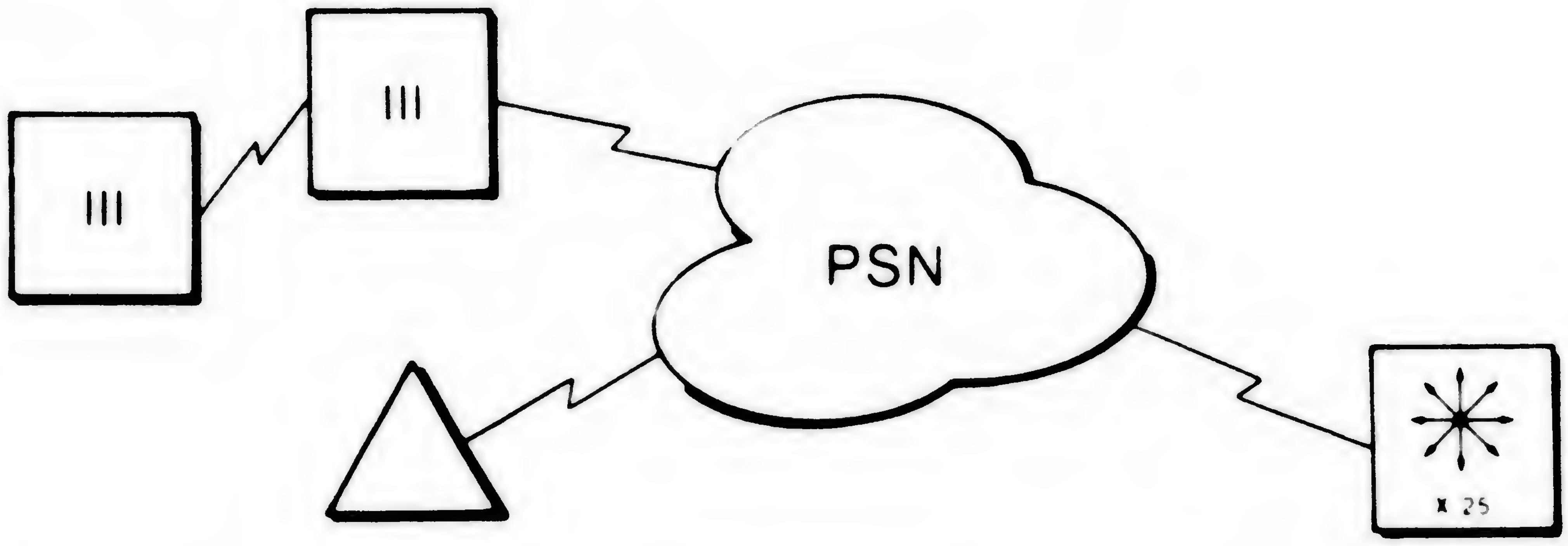


Figure 3–7: DECnet Router/X.25 Gateway Connections

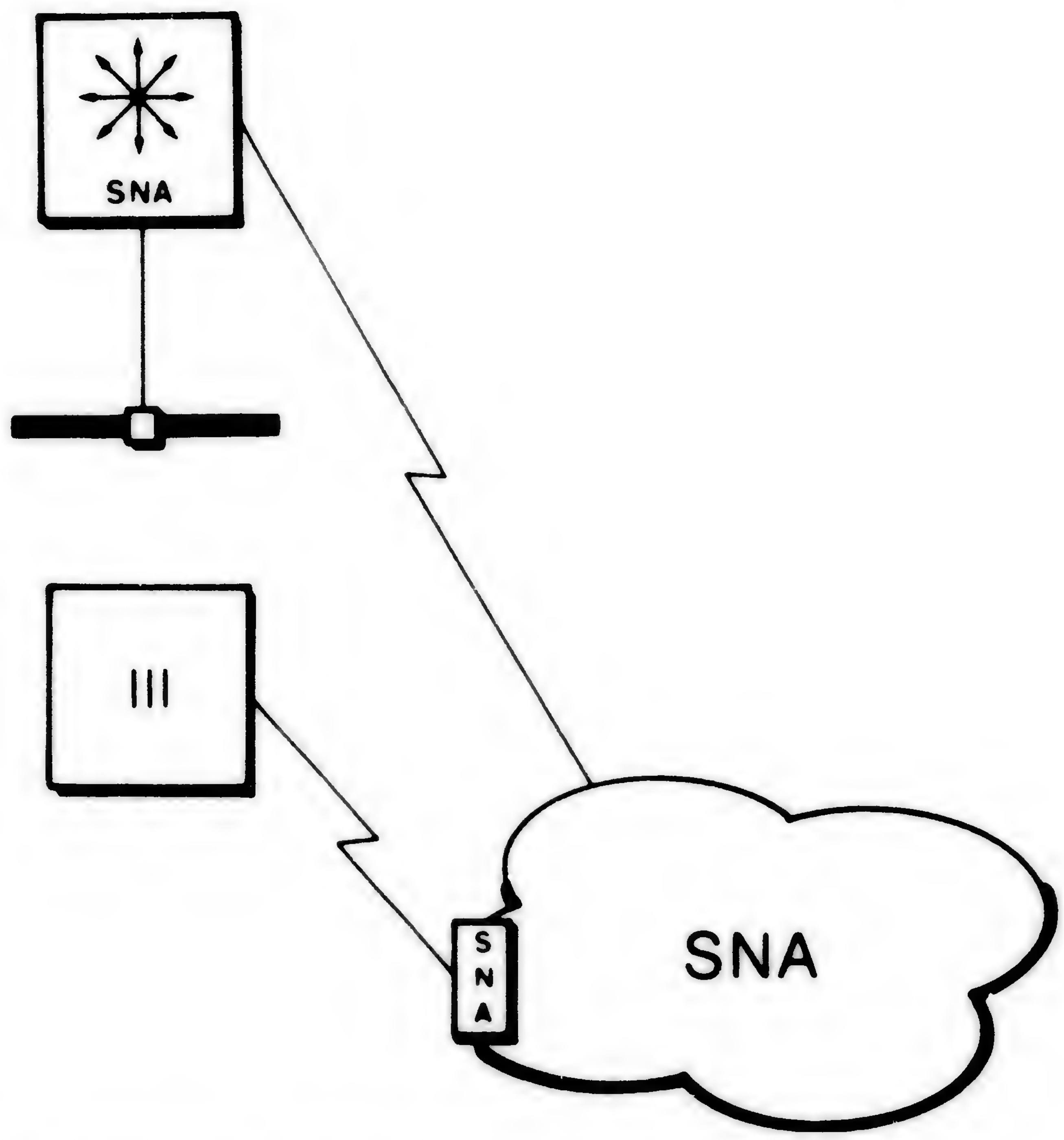


Figure 3–8: DECnet–SNA Connection

3.2.2 Building Local Area Networks

In building a local area network and using the Phase IV communications servers, you will, in effect, move most of your communications facilities out of the processing systems.

Four benefits are immediately realized in adopting this strategy:

1. **Increased processing capacity.** Communications servers relieve host nodes of routing and terminal support processing, enabling more computer cycles to be devoted to application processing.
2. **Reliability.** Unless physically damaged, the local area network cable never goes down.

3. **Configuration flexibility.** Network configuration can evolve by changing cable layout and by adding hosts and communications servers to the network without disrupting service.

4. **Economy.** The time and cost involved in putting a LAN in place to serve a given number of nodes can be significantly less than that which would be required to lay conventional cables to connect that same number of nodes. In most instances, cable footage requirements and site preparation costs are less.

A local area network will require Ethernet hardware and two or more host systems implementing Phase IV DECnet.

The Ethernet hardware will consist of:

- Ethernet coaxial cable (Figure 3-9). This is a 50-ohm, shielded cable that connects stations (hosts or communications servers) together. It is installed in segments up to 500 meters in length.

Figure 3-9: Ethernet Cable

- Transceiver (Figure 3-10). This device connects to the Ethernet cable by means of a non-destructive tap, meaning that the cable need not be cut.

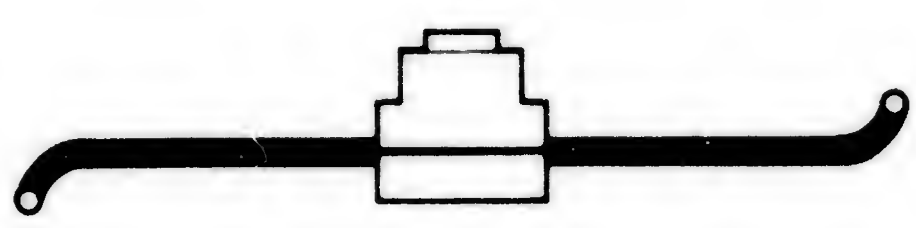


Figure 3-10: Transceiver on Cable

- Transceiver cable (Figure 3-11) This is a shielded, four twisted pair wire cable that connects the communications controller in a station to the transceiver.

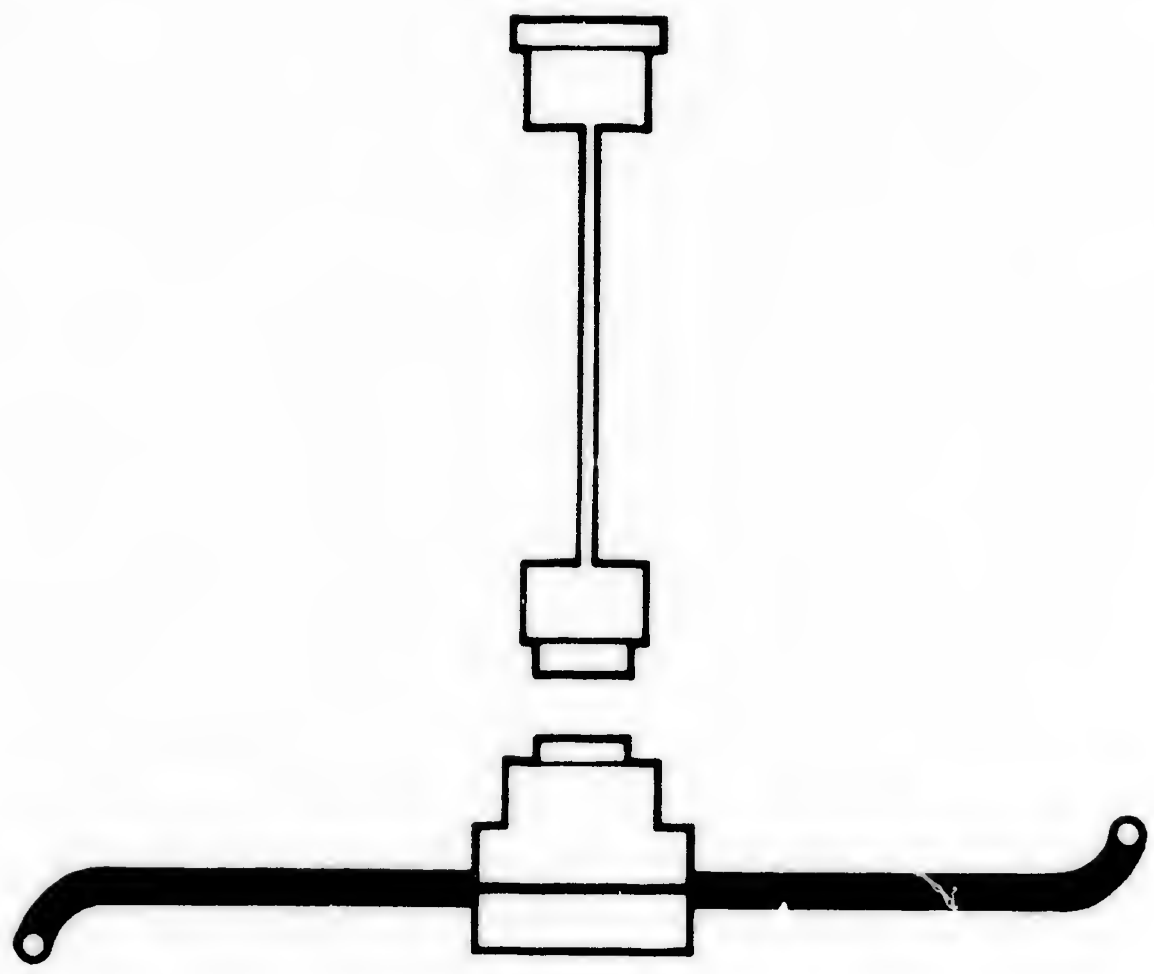


Figure 3-11: Transceiver Cable Connects to Transceiver

- Controller (Figure 3-12). This unit connects to the transceiver cable. The controller manages access to the cable.

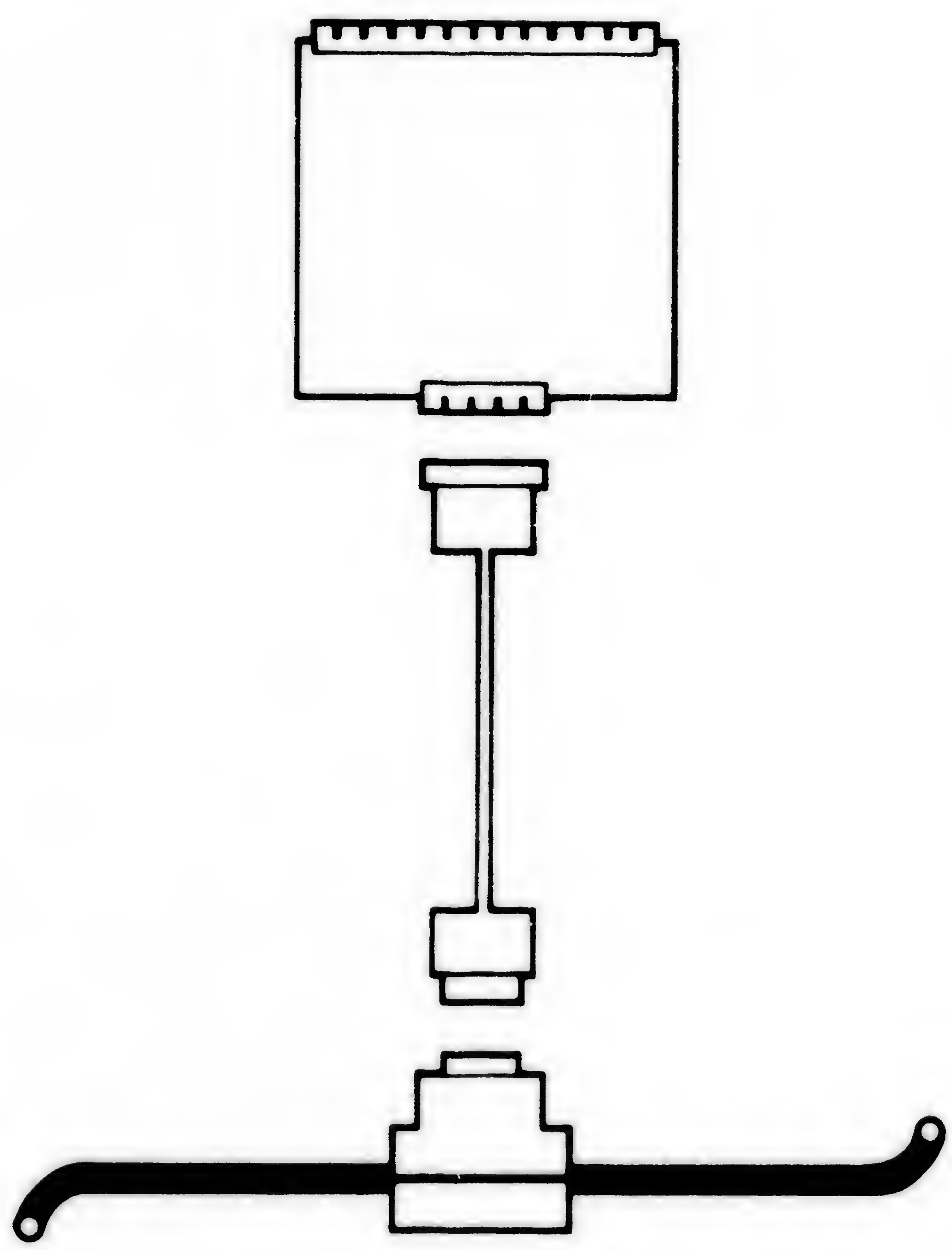


Figure 3-12: Controller Connects to Transceiver Cable

The systems implementing Phase IV DECnet are illustrated in Figure 3-13. The DIGITAL Equipment Local Network Interface (DELNI) provides an economical means for connecting an array of Phase IV processors to the Ethernet cable. This interface houses eight transceiver ports, each appearing functionally identical to the standard Ethernet transceiver (H4000). A ninth connector enables the grouped processors to be connected with an Ethernet cable. When this connection is made, each of the nodes on the DELNI appears to be a fully independent operating entity to other nodes on the Ethernet cable.

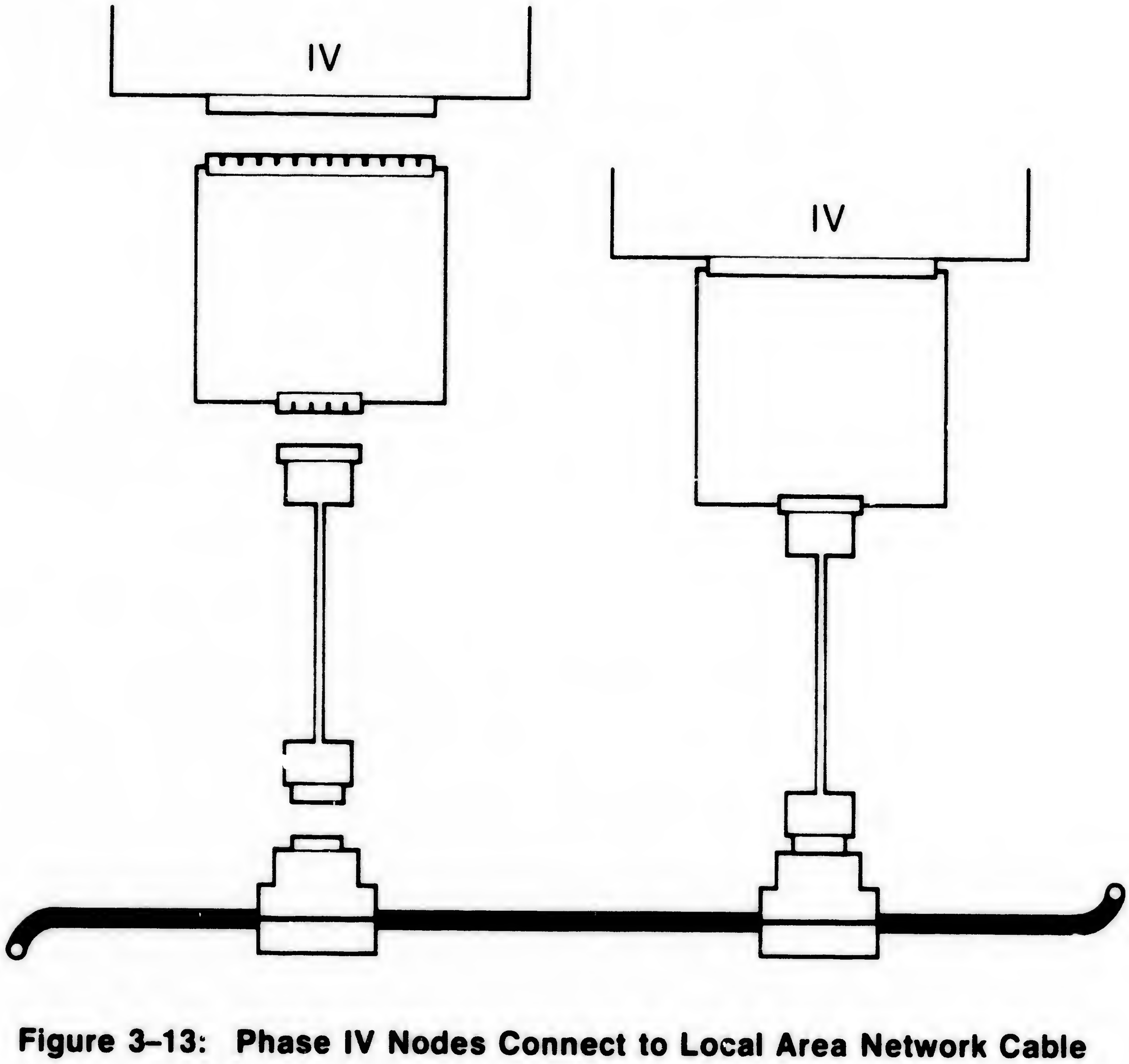


Figure 3-13: Phase IV Nodes Connect to Local Area Network Cable

A component called a repeater enables you to extend the local area network by joining multiple segments of coaxial cable. A local repeater links cable segments separated by not more than 80 meters. A remote repeater, using fiber optic cable, links cable segment separated by up to one kilometer. See *DIGITAL Ethernet Products and Services* for more detailed information.

To assure that users can continue to exercise a proper level of control over network operations and configuration, network management capability in Phase IV DECnet has been extended to cover network elements introduced in conjunction with LAN communications.

3.2.3 Communications Servers

Communications Server products, including the DECnet Router, the DECnet Router/X.25 Gateway and the Terminal Server contribute further to moving communications lines out of the user environment.

Server products act as network front ends. In so doing, they provide an effective means of communications from node-to-node, from terminals to any node in the network, and from network-to-network.

Because they can be shared by all of the processors on the LAN, and in the case of the Router Server and Gateways, even by nodes in wide-area networks, they are very cost-effective. Complete routing or Gateway capability need not be purchased for each node.

See Chapter 4 for a closer view of the communications server products.

3.2.4 Gateways

Gateways act as communications servers that link DECnet networks to other networks.

The X.25 Gateway is a DECnet Phase IV product that provides a path from a DECnet node to a DECnet or nonDECnet node on a Packet Switching Network. Although DECnet nodes can communicate with other DECnet nodes on a PSN without benefit of the Gateway, certain application-based considerations could make the Gateway path more practical.

The SNA Gateway enables Phase III and Phase IV DECnet nodes to communicate with an IBM mainframe in a network defined by IBM's Systems Network Architecture.

See Chapter 4 for a closer view of these two Gateway products.

3.2.5 Networking Personal Computers

This section outlines several networking configurations for PRO/DECnet nodes and the functional characteristics of these networked personal computers.

3.2.5.1 PRO/DECnet Configurations — PRO/DECnet enables DIGITAL's line of Professional personal computers to be networked to the LAN cable individually (Figure 3-14), or to the LAN cable in groups attached to the DELNI (Digital Equipment Local Network Interface), see Figure 3-15.

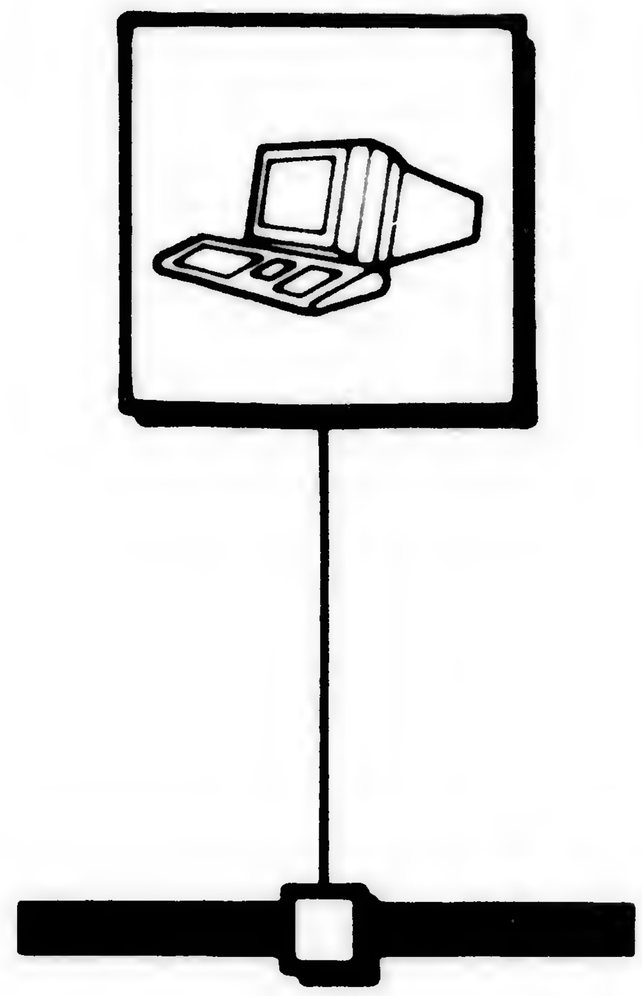


Figure 3–14: Individual Personal Computer Networked to a LAN Cable

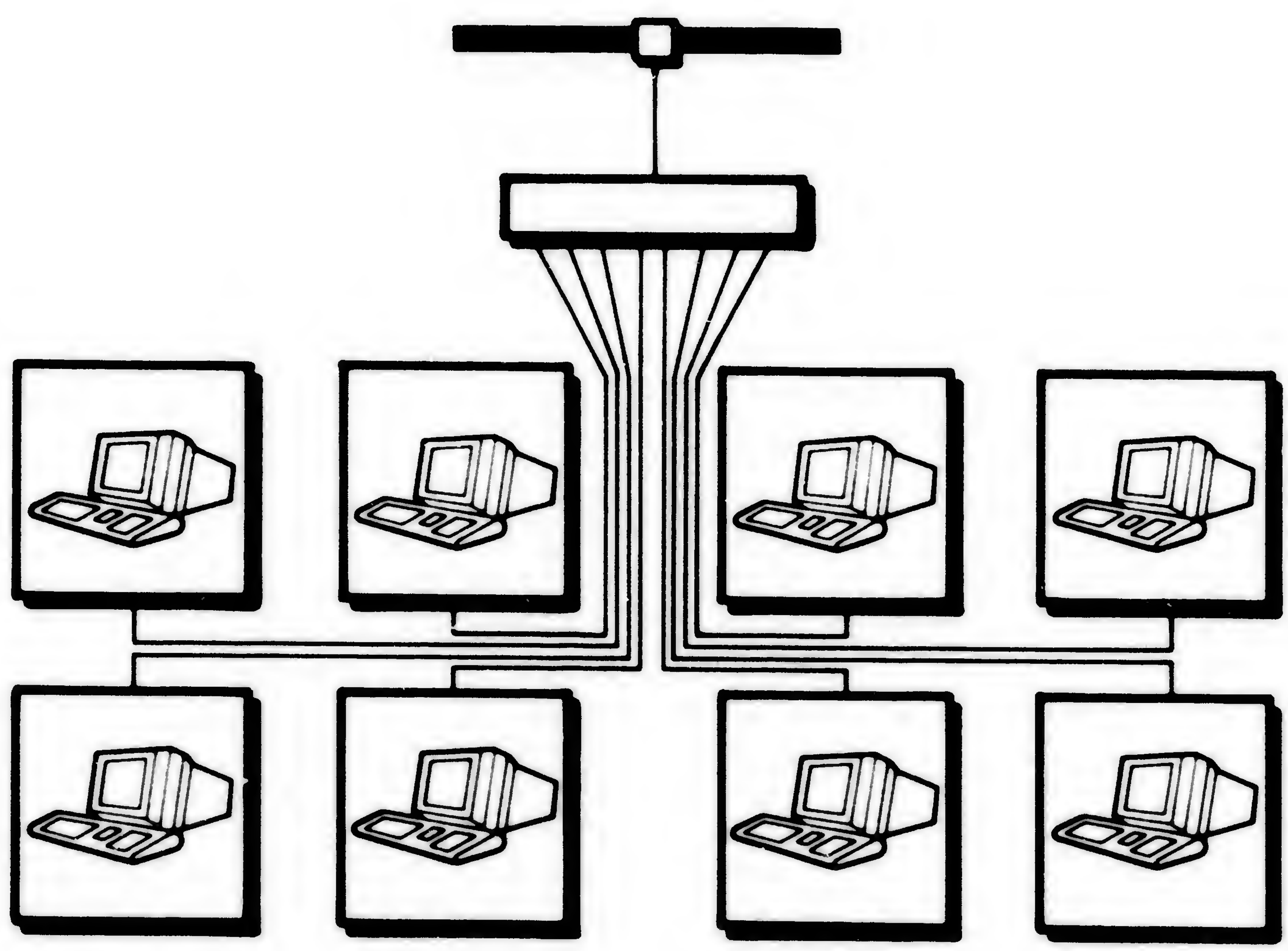


Figure 3–15: Linked Personal Computers Networked to a LAN Cable via the DELNI

In any of the illustrated configurations, the user can optionally disconnect from the DELNI or from the network and use the Professional as a standalone workstation.

When connected with a LAN as an individual node or as a node on a DELNI, a PRO/DECnet node can communicate with any other node that is directly or indirectly connected with the same LAN cable. When connected with the LAN, the PRO/DECnet node can access resources on the greater network. In terms of routing capability, whether coupled and connected to the LAN or individually connected to the LAN, the PRO/DECnet node is always an end-node.

PRO/DECnet nodes have the same functional range as do other DECnet host nodes. They support applications processing, and in conjunction with other general-purpose nodes, they support connections with Router Servers and Gateways, program development and the same set of communications protocols as do other Phase IV nodes.

The major difference between PRO/DECnet and other nodes is in how the user chooses functions to be performed, and in how those functions are executed. Network management, programming, and terminal user functions in PRO/DECnet are menu-based, as opposed to utility or command based on other systems. The PRO/DECnet user sees a list of functions on the terminal screen (a menu), and selects the desired one for execution. Selection is equivalent to execution.

3.2.5.2 PRO/DECnet Functional Characteristics — The user interface to PRO/DECnet functions is menu-based. When power is turned on, a menu is displayed on the screen, offering a choice of functions.

You can, for example, choose to do word-processing, use communications services, disk (or diskette) services, and print or file services. You can run applications, develop programs, and, intermittently, check for messages on a split-screen *message board* in the course of performing any of these functions. After selecting the function you want to perform, a submenu appears, enabling you to specify the precise action you want to take with respect to that function.

Because the programmer interface to PRO/DECnet is similar to that of DECnet-RSX nodes, most network applications are transportable. Also, because this product is designed in accordance with Digital Network Architecture, it implements the same set of protocols as do other DECnet nodes. Application programs that use the network, therefore, need not be concerned with certain basic communications functions.

The operating procedures and the documentation prepared for PRO/DECnet are designed for the non-technical user. From a design standpoint, the PRO/DECnet node is regarded as a user's private resource. As such it is built to be wholly controlled by that user. Extensive and easy to access HELP files and user manuals enable non-technical personnel to initialize, operate, and troubleshoot both the system and a limited aspect of the network. Full network troubleshooting remains the responsibility of experienced technical personnel.

3.3 Evolving Capabilities

Users upgrading from Phase III to Phase IV configurations will find that many existing capabilities have been extended to make functions easier to execute across the network, and to provide network management tools that cover the new network components.

Capabilities available in Phase III, and upgraded in Phase IV, include:

- Establishing a logical connection between a local terminal and a remote node.
- Maintenance capabilities.
- Increase in the number of addressable nodes supported.
- Data link access extended to Ethernet.

Each of these upgraded capabilities is described in the following.

3.3.1 Network Virtual Terminals

The network virtual terminal capability enables terminal users on local Phase IV DECnet nodes to establish logical connections with remote Phase IV DECnet nodes.

When the logical connection is established, terminal users can issue commands for execution on the remote node and access resources located there.

3.3.2 Extended Maintenance Capabilities

The following maintenance capabilities, available in DECnet-VAX and DECnet-RSX, have been extended to operate over the Ethernet.

- **Down-line load.** You can send a copy of a system image or other file over the Ethernet to the main memory of a target node.
- **Up-line dump.** You can send a copy of a target node's memory image over the Ethernet to a file at a host node.
- **Loopback testing for data link integrity.** Ethernet protocol manages this maintenance operation for nodes on the cable; DECnet protocol manages similar testing of non-Ethernet data links.
- **A terminal on a host node can act as console terminal on a remote node.** You can manage operation of a remote node by means of a terminal on a local node.

3.3.3 Number of Addressable Nodes

DECnet networks can now consist of up to 1,023 nodes. New routing techniques and utilization of communications servers to off-load routing processing make possible this fourfold increase over Phase III in potential network size.

3.3.4 Data Link Access in Phase III and Phase IV

DECnet nodes and nonDECnet systems can communicate with one another over the Ethernet cable. Using this facility, communications are effected by means of functions in the Physical and Data Link Layers of the architecture. Functions operating at this level of the architecture will deliver messages between computers. The user, however, must write the programs that interpret these messages.

Communicating DECnet nodes wishing to perform functions in accordance with nonDECnet protocols can use the same facility.

3.4 Compatibility with Phase III

To continue to serve users who have evolving network requirements, Phase IV DECnet is compatible with Phase III products. Utilities and services that operate among Phase III products continue to operate between Phase III and Phase IV products.

Programs developed for Phase III will run on Phase IV.

As previously noted, Phase III nodes can communicate with Phase IV host nodes directly, or by way of a DECnet Router Server.

Application Scenario #1: ACCOUNTING

Local and Remote Departments Interact and Update Centralized Data Base

Communications Problem: How can I enable technical and non-technical users, related groups, and related departments to communicate freely with one another, and give all of them access to current, centralized information?

Application/Environment Example: The Budget, Accounting and Audit Departments of a municipality's Finance Department are located on different floors of the same building. A centralized computer facility and programming staff serving each of these departments is located on still another floor along with administrative offices.

At the beginning of each fiscal year, the Budget Department turns over a tape of the new budget to the comptroller's office. This tape is processed by the comptroller so as to structure budgetary allocations in accordance with valid accounts. For the rest of the year, the Accounting Department maintains account records, while the Audit Department verifies transactions, and authorizes payments against funds budgeted for each account.

Approximately 75 different types of transactions can be made against accounts. Working groups in each of the departments are organized by transaction type. In addition, an inquiry group that researches records in order to respond to vendor inquiries, is maintained in the Audit Department. The inquiry capability is also frequently used by administrative personnel.

Over the years, the accounting techniques employed kept pace with available technology. The system evolved from manual, to accounting machine, to computer-based/punched card input operation, and then to a CRT-terminal/centralized mainframe configuration. This last redesign required laying cables throughout the building, linking terminals to controllers, and controllers to the mainframe. As cable footage increased, so did site preparation and line maintenance costs.

The next step in network development will tie remote municipal agencies to the centralized system. This arrangement will facilitate direct input from these remote sources. Because the application system edits input and subjects data to error processing before accepting it, any corrections that may have to be made will be made at the source. The time currently spent on adjustment processing by comptroller personnel will be reduced. The remote agencies will also be provided with the ability to inquire against specific accounts in the accounting data base.

Because they serve as individual workstations and facilitate individual to individual, individual to group, group to group, and workstation to local and centralized data base communications, DIGITAL Networking Products such as VT100 terminals connected with DECnet-VAX nodes on local area network cables respond to the requirements imposed by such

projected configurations. Not only do the DECnet VAX nodes offer file transfer and remote node access capability, but they also promote inter-group communication by means of a dialog facility. Site preparation and line maintenance costs are lowered, communication reliability is upgraded, individual to group, and group to group interaction is improved, all within the context of a compatible network architecture.

Incorporation of additional functions such as word processing and network mail into the same network does not require network reconfiguration.

Whether instituted in accounting, marketing, purchasing, or other corporate environments, such an integrated approach avoids the problems resulting from uncontrolled acquisition of personal computers, and mail and word processing systems that often turn out to be incompatible with one another and with established data bases.

Application Scenario #2: RESEARCH

Scientists, Technicians Share Resources over Local- and Wide-area Networks

Communications Problem: How can many autonomous computers, housed within a 3,000-foot radius of a central site, access and use special-purpose graphics devices and large, fast scientific computing resources located at that central facility?

Application/Environment Example: In each of more than 40 buildings at a 400-acre government research facility, groups of scientists and technicians are using computers to solve specific but related problems. Some are studying the effects of space flight on the human organism; others are analyzing the structural integrity of spacecraft and aircraft under simulated and actual flight conditions. Flight conditions are simulated in vast windtunnels at the research facility; actual flight conditions are monitored at an off-site location. Figure 3-16 illustrates the general layout of the facility.

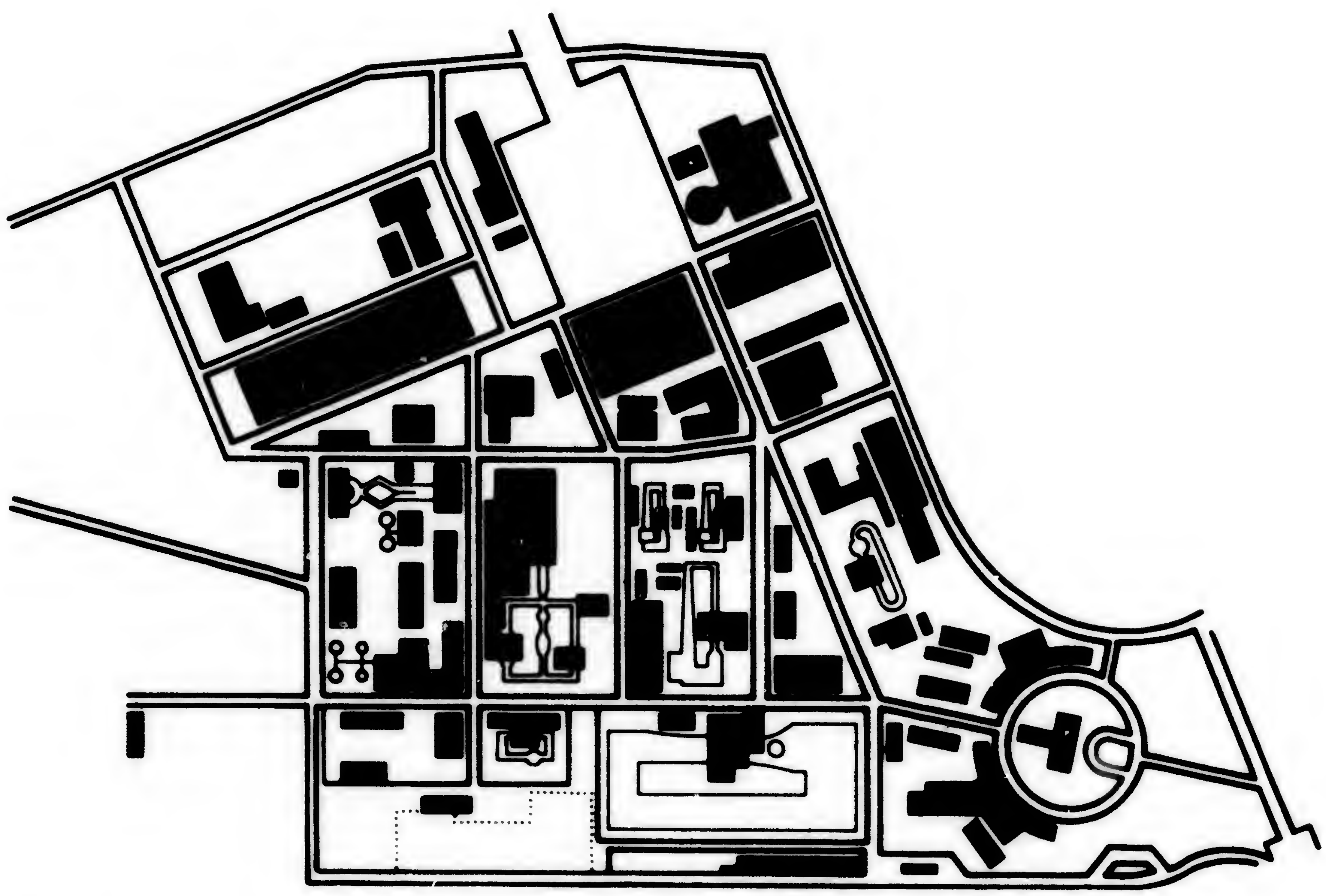


Figure 3–16: General Layout of Research Facility

Until the mid-1970's, when DECnet was first installed, local output from standalone DIGITAL systems was physically moved to a central location for further processing through graphics devices and very large, fast scientific computers. The first installation of DECnet accomplished two major goals:

1. It created an electronic link between designated outlying systems and the centralized resources.
2. It established a model for network development on technical and administrative levels that has since been profitably applied.

Subsequent installations of DECnet not only gave additional nodes the ability to use the central resources, but also enabled them to communicate with one another economically. DECnet's routing capability permits node-to-node communication through intervening nodes. No direct physical connection is required, thus reducing the need for physical lines, interface hardware, and maintenance costs. This feature also improves overall reliability, since alternative routes around failed lines or nodes are automatically taken.

Figure 3–17 illustrates the communications paths, implemented through DECnet, from outlying and off-site facilities to the central location.

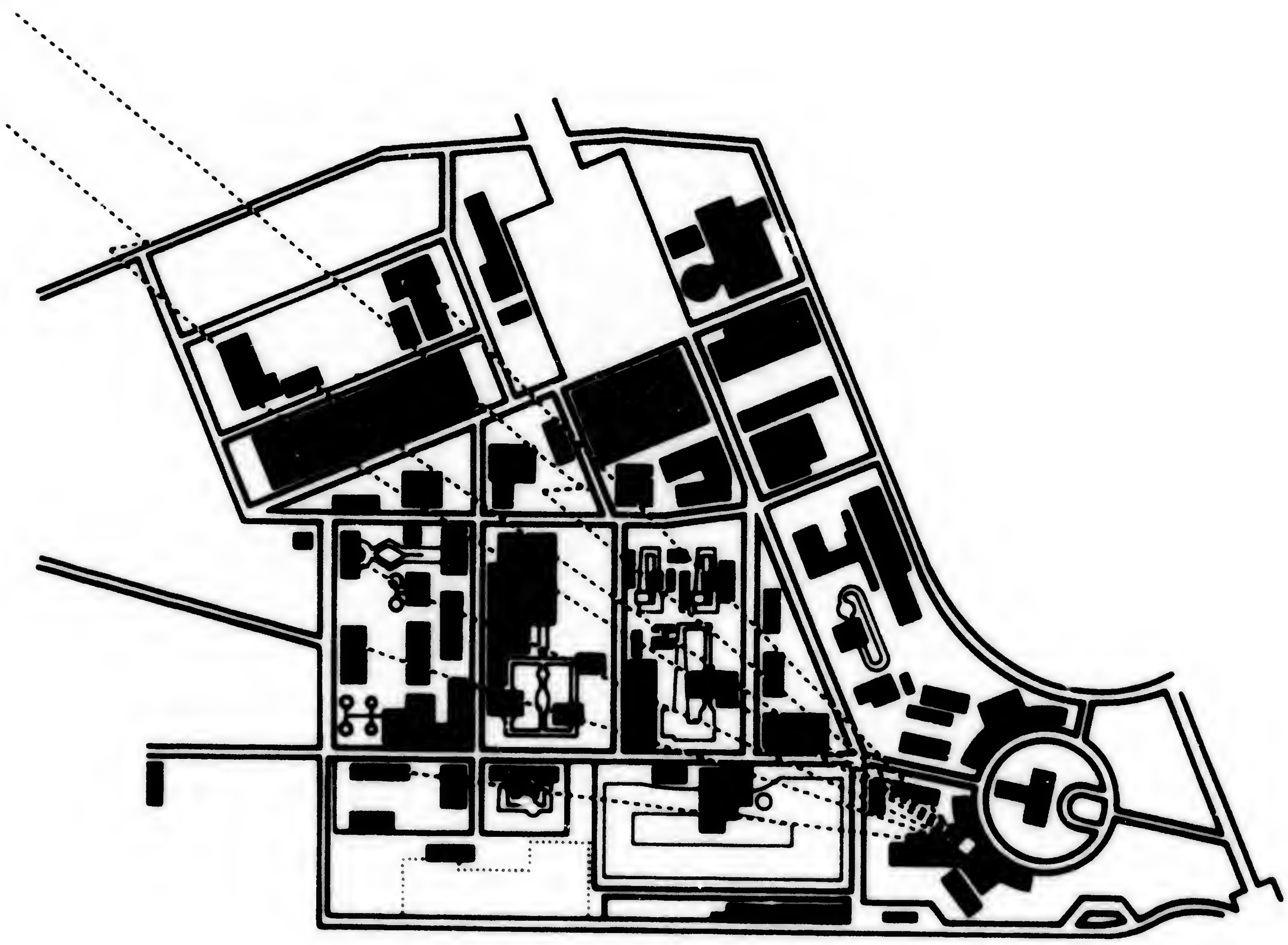


Figure 3–17: DECnet Communications Paths at Research Facility

In its most recent version, the entire network — applications, processing and communications capabilities, centralized and distributed resources — is at the disposal of each researcher (within security and privilege constraints).

Just what affect Phase IV DECnet will have on such networks depends on specific priorities. Local area network configurations linking processors, server products, Gateways, and networked personal computers offer flexible, but well-defined topologies for working at individual, inter-group, multi-group, facility-wide and world-wide levels. The communications facilities and resources of nonDECnet networks can also be made available, through these products, to researchers at DECnet workstations.

The products that implement DECnet Phase IV capabilities are discussed in Chapters 3 and 4.

Application Scenario #3: FINANCE/MARKETING
Remote Users Get Access to Non-Portable Applications

Communications Problem: How can I give multiple, remote locations access to advanced processing capabilities that cannot run on the remote computers?

Application/Environment Example: Several years ago, this corporation initiated an advanced development effort dedicated to national and international financial modeling, and market simulation. A significant investment in personnel, equipment, research facilities, and training programs established a state-of-the-art R&D group dedicated to development of these applications.

To facilitate inter-group communication and contact with related corporate functions (Treasurer and Marketing), the effort was centralized at corporate headquarters. Such localization also simplified special-purpose computer purchase, installation, and project coordination. Unless communications requirements were satisfied, however, centralizing the effort could have had some negative aspects.

Corporate-wide dependencies were apparent. Groups outside of the headquarters domain were specified as sources of input and users of program output.

Unless properly dealt with from a communications standpoint, the isolated R&D group could have proceeded to develop powerful, advanced programs that would have had limited utility because their results could not have been easily transported, and the applications could not easily have been accessed by remote user groups.

Investment in the financial models would have been threatened because input/output could not have been provided in a timely manner. Large-scale transaction-processing applications that could be profitably run only in response to timely model output, would have been paralyzed. Similarly, the value of the market simulation would have been questionable because delayed input/output would have dulled system sensitivity to changes in market behavior and in conditions that influence it. Hopes of interfacing the market simulation (whose output figured in new product development and release planning) with production scheduling and purchasing would have had to have been deferred.

The communications backbone, a DECnet network, made up of products described in Chapter 3, served as the communications medium for the corporate-wide network. It was put into service to link the new processing capabilities with specified remote user groups. One of the nodes contributing to information management functions in the DECnet network, was defined to the nonDIGITAL special-purpose computer as a supported device. This node then served as a Gateway, linking users of the DECnet network with the advanced, but non-portable programming functions.

Chapter 4
Communications Servers

These DIGITAL networking products consist of the following dedicated function nodes:

- **Router Server.** This server performs routing functions for Phase III and Phase IV DECnet nodes.
- **Terminal Server.** This server enables attached terminals to log on to any supported DECnet node.
- **Gateway to Packet Switching Networks.** This server supports DECnet-DECnet and DECnet-nonDECnet communication over Packet Switching Networks that implement communications protocols based on the X.25, X.28, X.29 and X.3 recommendations of the CCITT.
- **Gateway to SNA.** This server connects Phase III and Phase IV DECnet-VAX nodes with networks defined by IBM's Systems Network Architecture.

The Router Server off-loads communications processing overhead from host systems, thereby making more computer cycles available for application processing. The Terminal Server reduces the number of terminal host direct connections required while providing multihost access to Phase IV nodes. The Gateways extend DECnet topologies into areas governed by nonDECnet protocols. IBM SNA networks and X.25 Packet Switching Networks are, in effect, incorporated into the DECnet topology by means of the Gateways.

Application Scenarios #4 and #5 show how these products can be applied individually or in combination to solve communications problems and extend network reach.

Installed in Phase IV or combined Phase III/IV configurations, these communications servers become shared resources for all network users, thereby eliminating the cost that would be incurred if each node needed its own specific server capability. Functions are available for all supported terminals and processors, and the cost of the node and the connecting lines can be shared among all users.

In common with all DECnet nodes, these servers provide management and maintenance features that permit their operations to be monitored and controlled from local or remote locations.

Each of the communications servers is discussed in separate sections following.

4.1 The DECnet Router Server

This communications server performs *off LAN* routing functions for one or more Phase III or Phase IV DECnet nodes directly or indirectly connected with an Ethernet cable. In so doing, it permits networks to be built using lower cost end-node processors without sacrificing adaptive routing capability. See Figure 4-1.

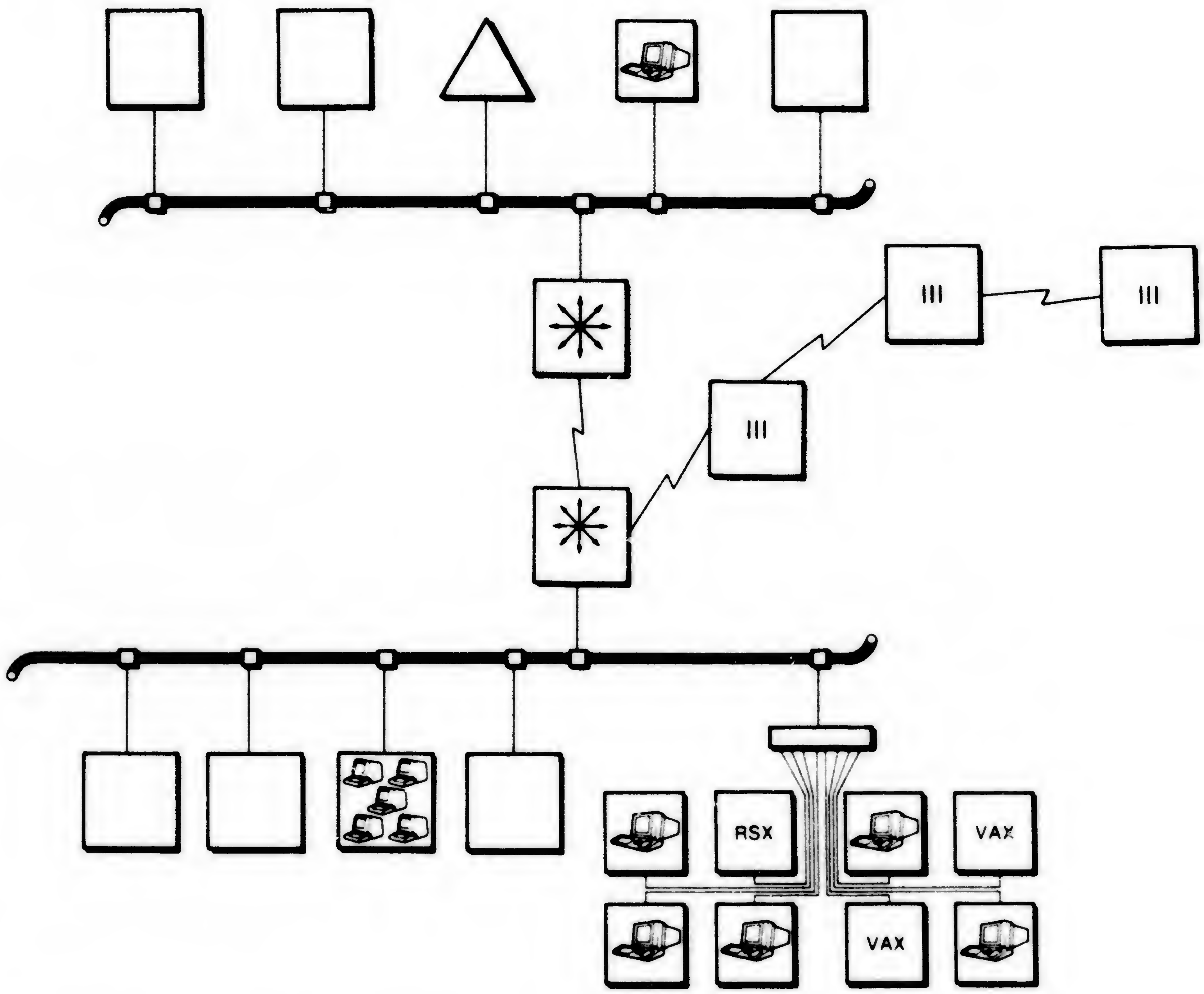


Figure 4-1: Router Servers in a Phase III/Phase IV Configuration

In Figure 4-1, all the nodes on one of the Ethernet cables are connected with all the nodes on the other cable and with the Phase III network by means of the Router Servers. The end-node on the Phase III network has access to all facilities in both local area networks by way of the servers.

In establishing the connections indicated in Figure 4-1, the dedicated routers off-load much of the communications processing load from the nodes that it serves. Memory and computer cycles that may have been required for routing, if these nodes had to be configured with a route-through capability, can now be applied to applications processing. In networks composed of many nodes, this can result in a significant increase in application-directed computing power.

Further economies are derived from router compatibility with Phase III nodes. Not only is investment in equipment and applications protected, but the router also provides an orderly mechanism for giving Phase III nodes access to resources configured to the LAN cable.

Note that if all the nodes on an Ethernet cable are expected to communicate only with each other (see Figure 4-2), each can be configured as an end-node. Neither the Router Server nor a general-purpose node with a route-through capability would be required.

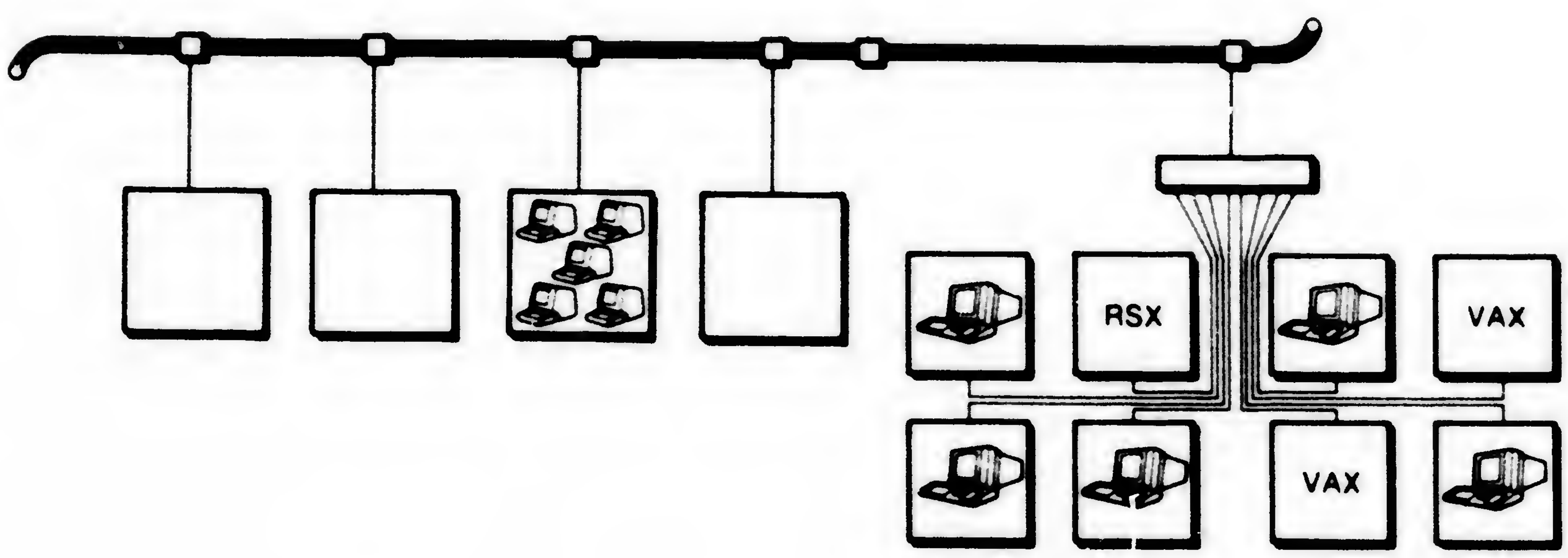


Figure 4–2: Router Server Not Required in this Configuration

The user of such a configuration, however, should keep in mind the potential cost of future network extension. Giving one of the existing end-nodes on the LAN a route-through capability, and adding necessary lines, may not be as cost-effective a solution as that offered by the Router Server.

4.2 The Terminal Server

The Terminal Server is a dedicated DECnet node that enables up to 32 connected asynchronous terminals to communicate with Phase IV DECnet nodes. Attached to an Ethernet cable, it provides a fully supported network virtual terminal capability to Phase IV DECnet-VAX and DECnet-RSX nodes. Terminals connect to the server by means of dedicated or switched lines.

Working at a terminal connected with the Terminal Server, you can log on to any of the supported nodes, using the procedures specified for that node, and then use any of the resources resident at the node. Configuration options also enable you to specify automatic logon to dedicated or preferred nodes.

In Figure 4-3, any terminal connected with the Terminal Server can access any of the nodes on both cables. Also a terminal on the server can communicate with an IBM mainframe in an SNA environment by simply logging on to a Phase IV DECnet-VAX node properly configured with Gateway Access Software. In Figure 4-3, for example, a terminal connected to the Terminal Server could log on to the rightmost DECnet-VAX node and then use its Gateway Access Software to interact with the IBM SNA network through the SNA Gateway. See Section 4.4 for information on the DECnet/SNA Gateway.

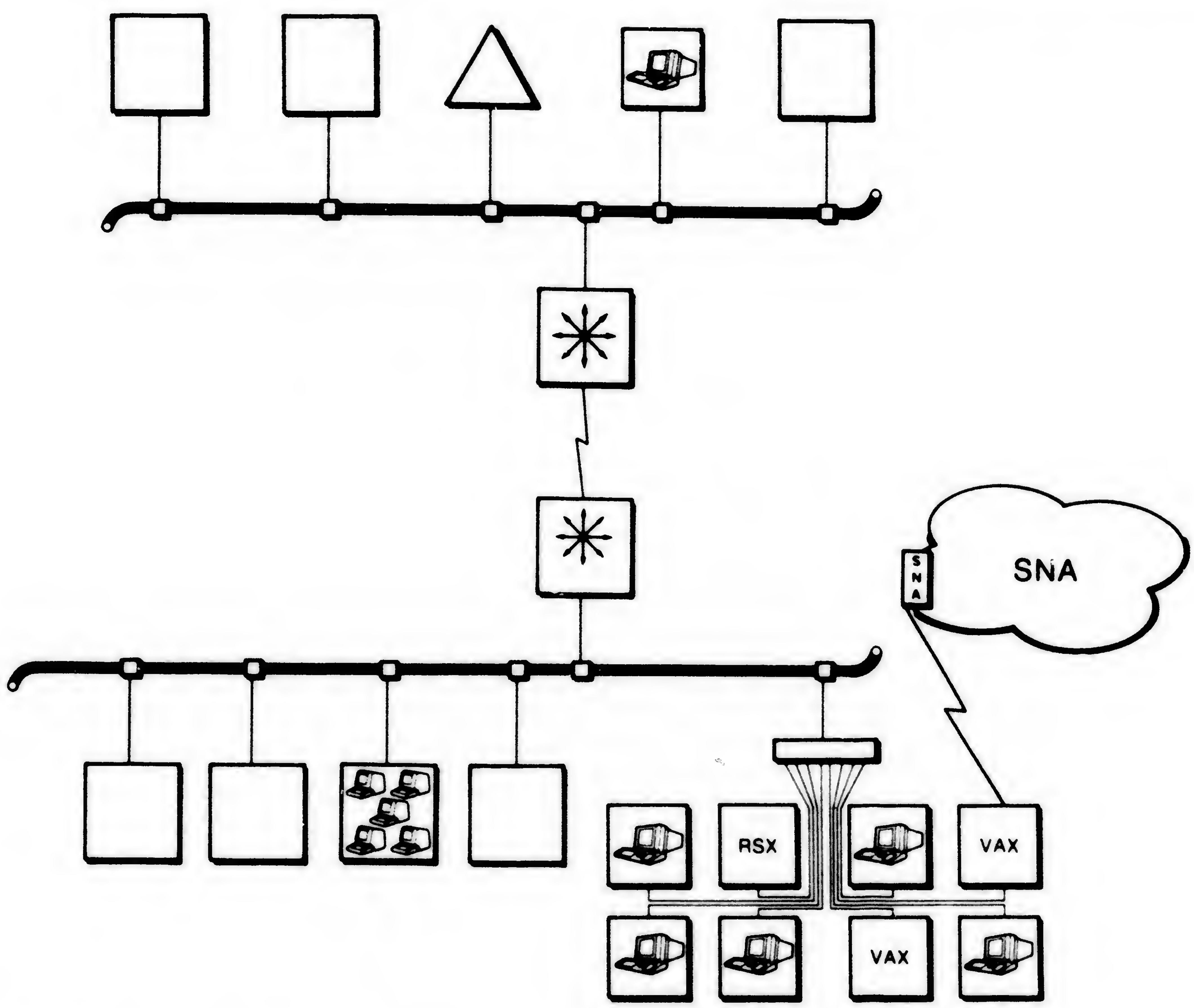


Figure 4-3: Terminals on Server Have Access to Resources on Local and Remote Cables

From a physical configuration standpoint, the Terminal Server reduces cabling requirements, and, as a consequence, installation and line maintenance costs.

For those portions of networks whose topologies are functionally determined, Terminal Server capabilities can prove very cost effective. Where, for example, it is useful to group programming or document preparation staffs in specific locations, the Terminal Server could provide a distinct advantage.

4.3 The DECnet Router/X.25 Gateway

The X.25 Gateway permits communication between DECnet nodes directly or indirectly connected with the local area network cable and DECnet nodes connected with a Packet Switching Network.

Each node that uses the Gateway to communicate with nonDECnet nodes must have the X.25/X.29 Extension Package software. The Extension Package supplies routines that, together with functions performed in the Gateway node, provide full PSI capability.

The X.25 Gateway runs concurrently with the Router Server. It allows users to access both DIGITAL and nonDIGITAL computers connected with the PSN. As with other communications servers, the X.25 Gateway makes possible certain operating economies. The cost of this resource can be shared by users, and the processor loading imposed by PSN interface processing is off-loaded from host nodes.

4.4 The DECnet/SNA Gateway

The DECnet/SNA Gateway enables DECnet-VAX nodes, properly configured with Gateway Access Software, to communicate with an IBM host in an SNA network. The Gateway can be configured on or off the LAN.

The Gateway is available not only to users of terminals physically connected to the VAX node, but also to those logically connected by means of the Network Virtual Terminal facility. Access to the Gateway, therefore, extends to users of terminals connected with a Terminal Server.

Although the communicating nodes are structured in accordance with different architectures (DNA for DECnet and SNA for IBM), messages flow between them through the Gateway as if they operated in accordance with the same set of protocols.

The Gateway mediates the differences between the communications rules imposed by each of the architectures, establishing a compatible environment in which the two processors ca ı nteract. Gateway operation is completely transparent to users at the communicating nodes.

The Gateway offers three types of access to the IBM mainframe:

1. **Remote Job Entry (RJE).** Gateway RJE access enables you to use the batch processing capability of the IBM mainframe, in addition to the resources available to any terminal on a DECnet-VAX host.

   Batch jobs, for example, consisting of daily production or transaction totals, or customer update information, can be prepared on the VAX node and then queued through the Gateway to the IBM mainframe to update centralized data bases. Job output from the IBM side of the configuration is processed through the Gateway and written to user-specified files in the DECnet network. These files are then available to the originating user, and, if required, to any user throughout the DECnet network.

2. **3270 Terminal Emulation.** Gateway 3270 Terminal Emulation enables any member of the DIGITAL family of VT100 terminals to act as a 3270 terminal with respect to the IBM SNA system.

   Such access is useful for applications requiring an inquiry/response capability between the interacting systems for issuance and completion of formatted screens exchanged between the systems.

   When not acting as a 3270 terminal, the VT100 can function as specified by the user throughout the DECnet network.

3. **Application Interface.** The Gateway's application interface software enables programs running in the VAX node to interact with a cooperating application in the IBM mainframe.

   The programs must be written to work together. Gateway procedures enable the programs to initiate communications with one another, to transmit and receive data, to respond to asynchronous events, and then to terminate the session.

In addition to providing the above described capabilities, the Gateway gives the system manager at the DECnet-VAX node the ability to monitor, control, and troubleshoot the Gateway.

The *DECnet/SNA Gateway Introduction* presents an overview of this product.

4.5 Communications Server: Hardware and Software

The DECnet Router Server, Terminal Server, and DECnet Router/X.25 Gateway Server are built on a common hardware base consisting of a pre-packaged PDP-11 processor with 512K bytes of memory. Resident software supports connection to an Ethernet cable, DECnet functions and protocols, and connections with terminals and communications lines.

The DECnet/SNA Gateway configured off the LAN is built on a hardware base consisting of a PDP-11/24 processor. It contains DECnet software, a protocol translation module, Gateway management software, and modules that support functions such as Remote Job Entry, 3270 Terminal Emulation, and program-to-program interaction. Hardware of the DECnet/SNA Gateway that connects with the LAN is similar to that used for the DECnet Router Server, Terminal Server, and DECnet Router/X.25 Gateway.

Installed in Phase IV or combined Phase IV/Phase III configurations, these communications servers become shared resources that can be used by supported nodes throughout the network.

Application Scenario #4: ORDER ENTRY/PRODUCTION SCHEDULING DECnet and SNA Networks Work Together

Communications Problem: How can I establish reliable communication between nodes in a DECnet network and an IBM mainframe in an SNA network?

Application/Environment Example: This company makes a very wide range of products, each being a variation on the basic product. Colors and weights, for example, might vary for each order, as might the finish and the packaging. Within each one of these parameters, dozens of options are available.

Production line setup, a relatively expensive operation, must respond to orders received on an unplanned basis for any one product or combination of products. Further, economic operation dictates that production line location must be as geographically close as possible to either the customer reception location, or to a mode of shipment that would make transportation economical.

To make this operation work effectively, production facilities must be specified as soon as possible upon order receipt. The system used consists of DECnet-VAX nodes at regional sales offices and production facilities, an IBM mainframe in a Systems Network Architecture configuration at corporate headquarters, and a DECnet/SNA Gateway linking the DIGITAL and IBM networks.

Orders are entered at the sales offices and transmitted to the IBM mainframe which runs selected data through a corporate-wide production resource file. Production facilities available now and within 30 days for the specific products are listed back to the sales offices and to each of the production facilities. Interaction between the plants and the sales offices by means of a DECnet-VAX on-line dialog capability then determines where the product will be manufactured.

The DECnet-VAX nodes that run at the sales offices and the manufacturing sites are part of a network that links interrelated company functions. The IBM mainframe in the SNA network runs in a corporate-wide management information system. In communicating with IBM, terminals at the sales offices use 3270 Terminal Emulation and the Application Interface functions available through the DECnet/SNA Gateway. The sales orders, which are, in effect, completed forms, are transmitted to an application in the mainframe. Formatted response is returned to the sales offices.

In interacting with the production facilities, terminals at the sales offices use DECnet functions to access files and engage in dialog with relevant personnel.

Further use of DECnet/SNA Gateway facilities takes place on a daily basis when the VAX nodes at the plants update the corporate production planning data base by means of the Gateway's Remote Job Entry capability.

Chapter 4 presents an Overview of the DECnet/SNA Gateway.

Application Scenario #5: DOCUMENT PREPARATION

Local- and Wide-area Networks Support Fast-paced Proposal Effort

Communications Problem: How can I give local and remote groups access to information stored in computers throughout the network, and provide a communications capability that enables these groups to interact frequently and rapidly?

Application/Environment Example: A well-managed and responsive proposal effort is essential to this engineering firm. Proposals developed in response to requests from government and private industry must be thorough, accurate and timely to merit consideration under competitive bidding. The firm must be able to draw upon information stored in computers at various sites, refine the material for specific application, identify facilities and personnel available for the project, develop cost information, detail corporate experience in similar efforts, and deliver a response to the proposal request by a specified time.

While original material is created by engineering staff, researchers assigned to specific parts of the proposal must investigate information stored in computer files at various facilities. This historical material is assembled by the researchers. Then, in iterative communication with field and home office management, technical, accounting, personnel, and facilities specialists, the basic material is refined and scrutinized for accuracy. Information *modules* developed in this manner are then submitted to proposal management to evaluate responsiveness to requirements. Another set of iterative procedures between proposal management and the researchers, and researchers and specialists throughout the company assures that the information developed is both accurate and responsive.

While this intercompany activity is going forward, proposal management is in continual contact with the issuer of the request, seeking clarification and obtaining update information. Frequently, this new material requires that changes be made to information modules that have already been developed. Additional iterative procedures must then be instituted.

The final phase of proposal preparation consists of turning information modules over to a staff of proposal writers who build a coherent, readable document from the many pieces. Drafts of the document must then be submitted to specified signatories until approval for submission is obtained.

Proposal management, researchers, and writers are based in the Washington D.C. area, while information resources and proposal contributors are located nationwide, and for certain projects, worldwide. Given the time constraints under which most proposal activity is conducted, rapid and reliable communication is critical.

A wide-area network linked by DECnet Routers and a DECnet Router/X.25 Gateway with several local-area DECnet and Packet Switching Networks is in general use throughout the company. For proposal efforts, it serves as the information storage and communications mechanism. Terminals connected with Terminal Servers (see Chapter 4) are used by the Washington D.C. groups to access world-wide information and to distribute information modules and drafts back to authorized sources for review and update.

With the Terminal Server incorporated into a local area network configuration at the Washington D.C. location, multi-terminal connections to local nodes are not required for the proposal effort. Throughout the network, in fact, computer cycles that are normally required to support terminal communications are available for applications processing.

In conjunction with experienced proposal management, this system assures that information presented in response to requests for proposals is up-to-date, accurate, properly reviewed, and assembled for presentation within schedule.

Chapter 5
DIGITAL-PSI Products

These DIGITAL Networking Products implement communications protocols based on recommendations made by the Comite Consultatif International Telephonique et Telegraphique (CCITT). These protocols have become generally accepted standards for communications over Packet Switching Networks (PSNs). DIGITAL's implementation of these protocols provides three categories of networking capability over PSNs:

1. DIGITAL systems can communicate with each other over a PSN.
2. DIGITAL systems can communicate with nonDIGITAL systems over a PSN.
3. Remote terminals, connected directly with the PSN or connected with the PSN through a host system, can communicate with remote systems over the PSN.

The PSN not only provides the communication path, it also takes care of all routing functions. The user need supply, in the transmission or by pre-arrangement, only the address of the receiving system or terminal.

DIGITAL Packetnet System Interface (PSI) products provide these capabilities to VAX/VMS, TOPS-20, and RSX-11M and M-PLUS systems. DECnet nodes incorporating this software can also communicate over the PSN. Figure 5-1 illustrates DIGITAL-DIGITAL communication over a PSN; Figure 5-2 adds a non-DIGITAL system to the network; Figure 5-3 adds remote and node-based synchronous and asynchronous terminals to the network.

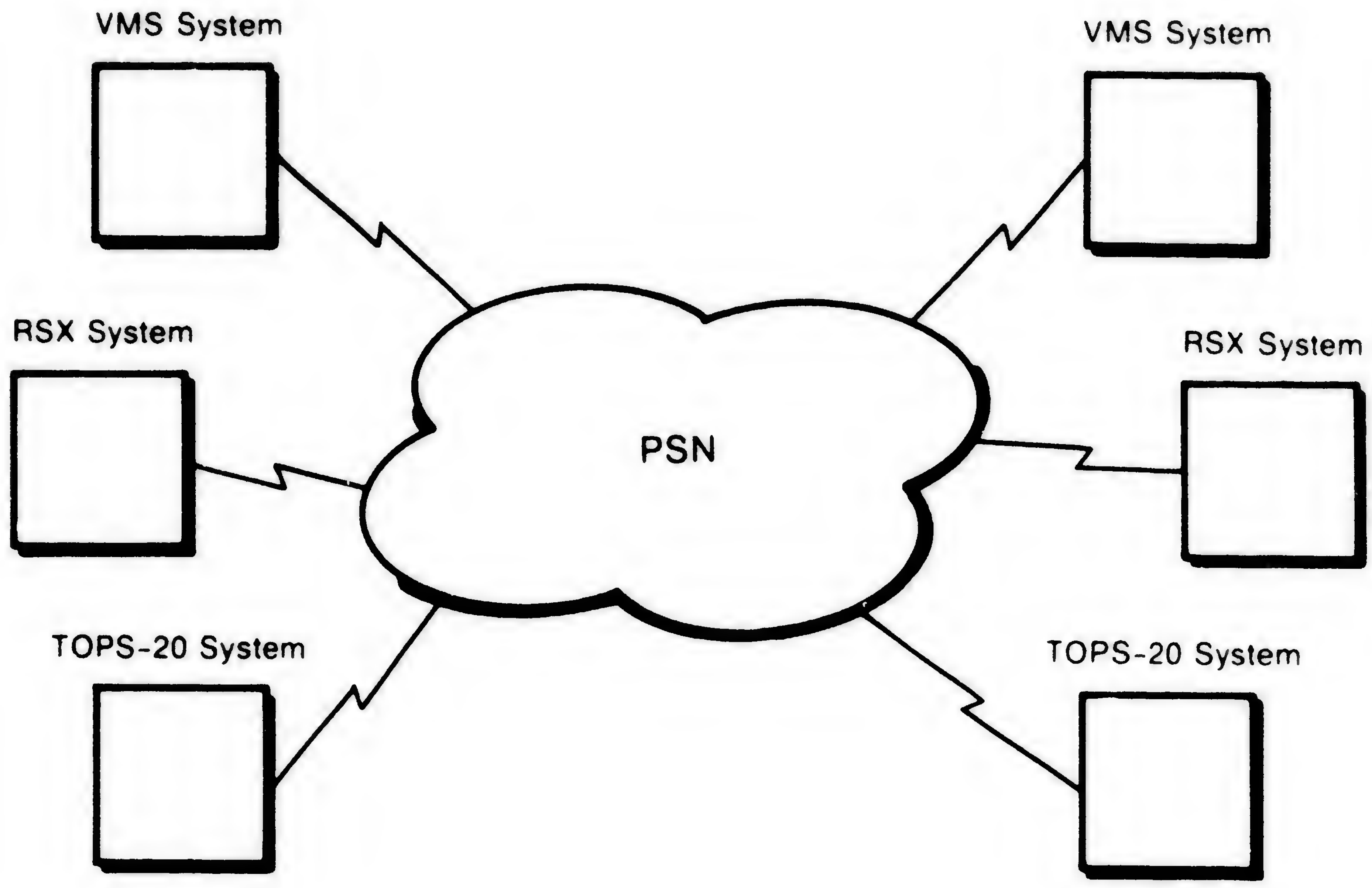


Figure 5–1: PSI-equipped DIGITAL Systems Networked Over a PSN

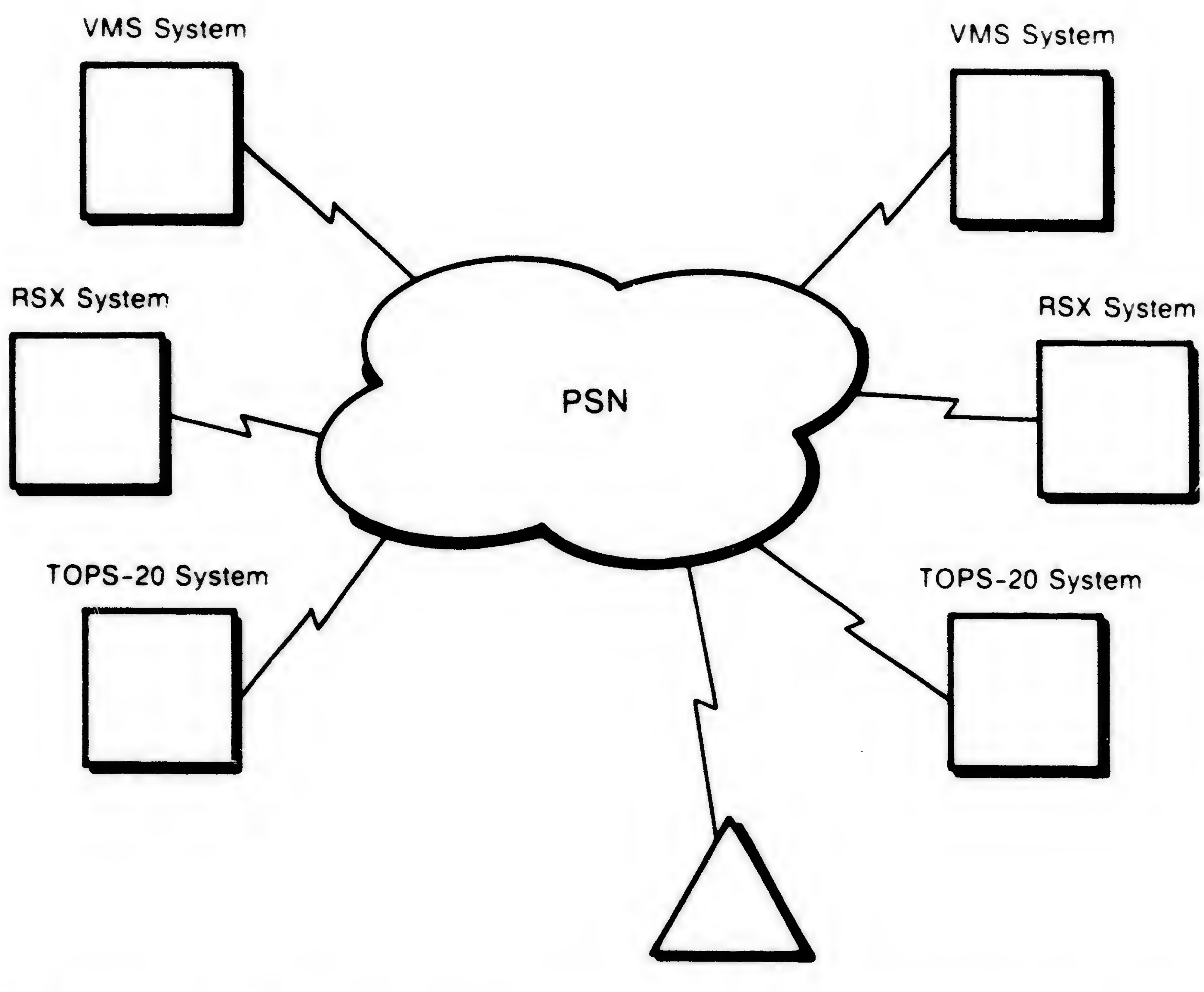


Figure 5–2: DIGITAL-to-NonDIGITAL Communication Over a PSN

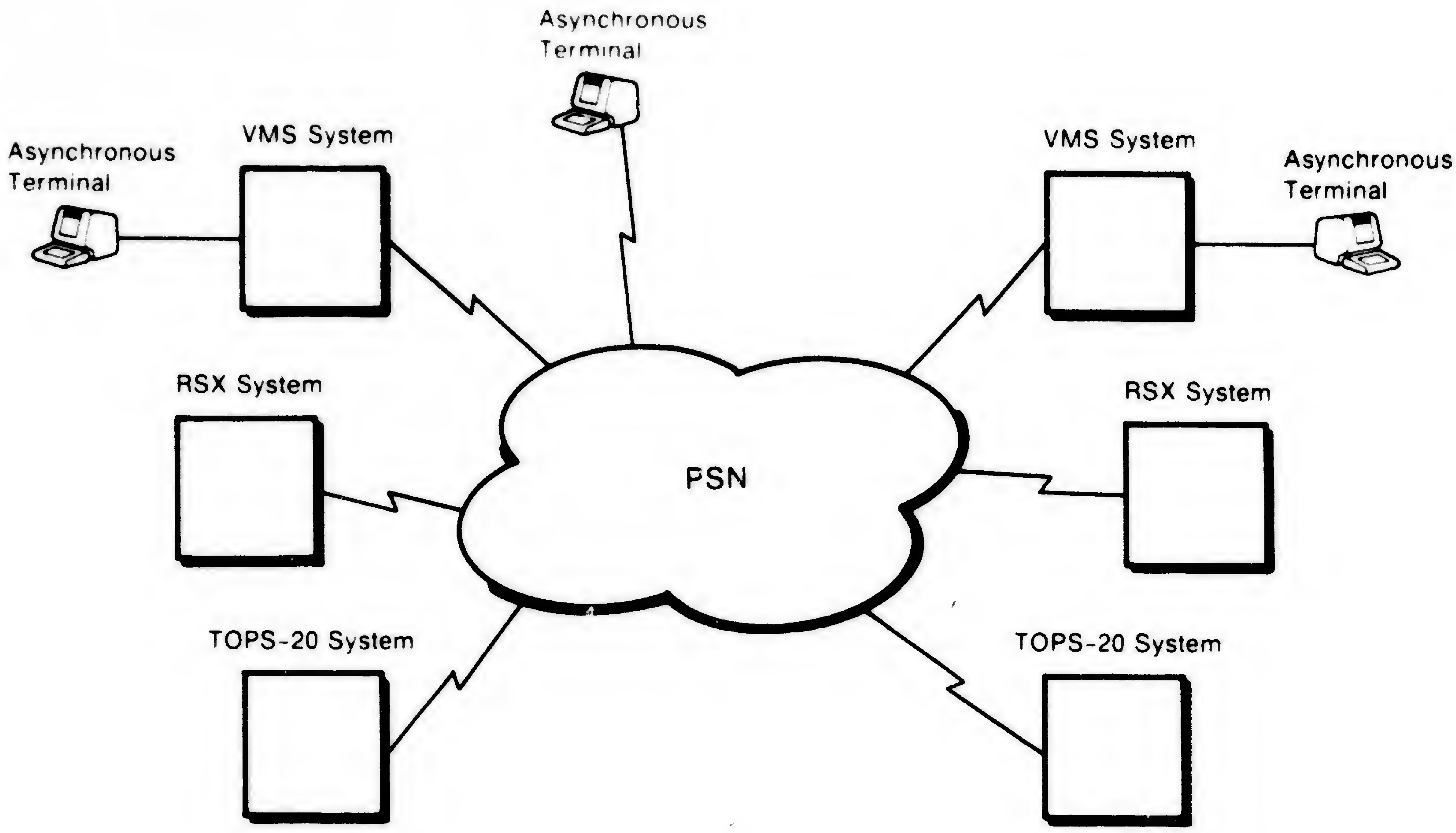


Figure 5–3: Terminal–Host Communication Over a PSN

The interaction among the user, the DIGITAL-PSI product, and the PSN follows this basic three-step pattern:

1. Together with the data you want to send, you supply the header information that the PSN needs. (PSN requirements are outlined in PSI product documentation, and are detailed at subscription time.)
2. The DIGITAL-PSI product at the source node formats your message into packets and puts it on the PSN in accordance with X.25 protocol.
3. The DIGITAL-PSI product (or foreign-vendor equivalent) at the destination computer or terminal takes the message off the PSN in accordance with PSN protocol requirements.

The role of the PSI product and the PSN are, for the most part, transparent to the user throughout this procedure.

5.1 PSI Products and the X.25 and X.29 Recommendations

Packet Switching Networks provide data communications services that, especially in low-volume asynchronous transmissions over long distances, can be more economical than those provided by other common carriers. Economies can result primarily because costs are based on the volume of data transmitted, rather than on the distance the transmissions are carried. Some PSNs also charge on a connect time basis; others do not.

In addition, PSNs guarantee message delivery or user notification. The user will get an indication of any error that occurs in transmission.

The increasing popularity of PSNs as carriers of digital data necessitated establishment of a standard to govern the interface between the network and computers and terminals that use it. In response to this requirement, an international committee, the CCITT, recommended the adoption of certain rules as standards for interfacing computers and terminals with the PSN. Four of those recommendations, X.25, X.29, X.3, and X.28 (which now serve as the basis for international standards), are implemented in DIGITAL's PSI products.

- The X.25 recommendation defines the protocol governing the interface between the PSN and computers and terminals that operate in packet mode.
- The X.29 recommendation defines the protocol governing communication between packet-mode and character-mode equipment connected with the PSN.
- The X.3 recommendation defines the protocol governing Packet Assembly/Disassembly (PAD) facilities on a PSN.
- The X.28 recommendation defines the protocol governing the interface between an asynchronous terminal and the Packet Assembly/Disassembly (PAD) facilities on a PSN.

DIGITAL PSI products are currently implemented for operation over the following PSNs:

DIGITAL PSI Products	**PSN**
Packet Switching Service	United Kingdom
Telenet	United States
TRANSPAC	France
Datanet 1	Netherlands
DATEX-P	West Germany

The ability to operate over other PSNs (DATAPAC, TELEPAC, TYMNET) is being incorporated into the DIGITAL PSI products. Current PSI products offer Field Configurable Network Software that enable them to run on national PSNs not yet fully supported, and on private networks that implement the CCITT-recommended protocols.

Application Scenario #6 illustrates a case of linked national PSNs moving data to and from remote terminals.

5.2 Building and Extending Networks with PSI Products

This section summarizes the facilities engineered into the DIGITAL PSI products that permit communication over a PSN.

5.2.1 DIGITAL-to-DIGITAL Communication

PSI products run in VMS, TOPS-20, RSX-11M, and RSX-11M-PLUS systems. Any of these systems, or DECnet nodes that incorporate the PSI software, can communicate with any other of these systems over a PSN.

The PSI software is either generated and/or installed in the system, depending upon operating system characteristics. A generation procedure takes the form of a dialog between the user and the software. Questions are posed on a terminal, and the user responds, customizing PSI capability and defining the environment in which it will run. As described in the documentation for each of the products, there are certain components and features of the PSI software that must be included in the configuration, and there are other features that are optional. Reference cards provided with some of the PSI products summarize the facilities available with each PSN.

Most of the optional features that can be selected during generation have to do with troubleshooting facilities or hardware configuration. Troubleshooting facilities offered on certain of the PSI products consist of tasks such as those that trace and interpret information on frames passing from level 2 of the X.25 protocol (which defines the link access procedure from the computer or terminal to the PSN) to a device driver. A dump analyzer task and high-level language libraries are included with the product and can optionally be selected.

Certain PSN facilities also permit options to be exercised. Communicating nodes, for example, can be either tightly or loosely connected. A permanent virtual circuit connects nodes over the PSN as if by dedicated line. A switched virtual circuit, on the other hand, connects nodes over the PSN as if by dial up. You specify the address of the nodes with which you want to communicate.

A series of other options that can be specified either on a per call basis or by prior arrangement with the PSN at subscription time can further customize the public communications facility to serve your specific needs.

DECnet nodes that incorporate PSI capabilities retain and can exercise full DECnet capabilities over the Packet Switching Network. These capabilities include the features listed in Section 3.1.2.

5.2.2 DIGITAL to Non-DIGITAL Communications Over a PSN

The protocol governing the interface between a PSN and a connected computer or terminal must be implemented in accordance with the CCITT recommendations. Therefore, any DIGITAL PSI product can be physically networked, via the PSN, with any nonDIGITAL system that similarly implements the X.25 recommendation. Any end-to-end interaction between users at such networked nodes must be defined and implemented by the user.

The ability to participate in a network with nonDIGITAL systems connected to a PSN is a further example of the balanced computing communications capability made available through use of DNPs.

5.2.3 Terminal–Computer Communications Over a PSN

Implementation of protocols based on the X.3, X.28, and X.29 recommendations enables DIGITAL PSI products to communicate with non-packet mode terminals, such as teletypewriters and video display terminals. Communication is effected through a Packet Assembly/Disassembly (PAD) facility that is either node-based or directly connected to the PSN. The PAD performs three major functions:

1. It assembles data received from character-mode (asynchronous) terminals into packets and forwards the packets to the designated node connected with the PSN.
2. It disassembles packets arriving from packet-mode computers, and transmits the messages, character-by-character at the acceptable speed, to the asynchronous terminal.
3. It handles virtual call setup and clearing, and reset and interrupt procedures.

Implementation of the X.29 recommendation in the DIGITAL PSI product, or in a non-DIGITAL processor, permits such communication between a remote, asynchronous terminal and a computer via a PSN, or between a node-based asynchronous terminal and a nonDECnet computer connected with a PSN (see Figure 5-3).

Application Scenario #6: PLANNING

Forecasting Input from the Woodlands: Terminals Use X.25 Networks

Communications Problem: How can I establish communications links between scattered remote terminals and a processor at corporate headquarters?

Application/Environment Example: A forest products company runs a forecasting system at corporate headquarters in an east coast American city. The system requires periodic input from remote locations — logging camps, plantations — located in various parts of Canada and the U.S. The input specifies the volume of standing timber and acreage devoted to hardwood and softwood in various stages of growth — from seedling on up. The forecasting system projects future inventories based on this input, and also calculates the consequences of variable harvest patterns for each type of wood.

To obtain input, the company circulates initial, intermediate, and final questionnaires to the plantation and logging camp managers periodically. Responses to the questionnaires, however, are not sufficiently timely or complete. Personnel at the remote sites have historically proven independent and not overly concerned with survey feed back to corporate headquarters. Since the input to the forecasting system was traditionally inadequate, its output was flawed. As a result, plans based on generated forecasts were never implemented.

The problem, obviously, has two aspects: managerial and technical. A technical solution, however, could resolve both aspects of the problem. From a communications standpoint, these are some considerations:

- Terminals at the remote locations could encourage timely and complete input through display of input forms. Final output of the forecasting/planning system, including harvest and planting patterns to be observed, could also be displayed at the terminals. Intermediate input/output could be similarly communicated.
- Both Canada and the U.S make Packet Switching Network communication available. These networks connect with one another. PSNs are known to be highly cost-effective for transmitting data in intermittent bursts over long distances.
- The capabilities of DIGITAL PSI products, with respect to X.25 and X.29 protocols, enable inexpensive, asynchronous terminals to communicate over these public networks.
- The capability of 3270 Terminal Emulators enable DIGITAL VT100 terminals to interact with an application in an IBM SNA or standalone mainframe as if it were a member of the IBM family of 3270 terminals.

The precise DIGITAL Networking Product solution to this problem depends primarily upon the configuration at corporate headquarters.

- If the forecasting system at corporate headquarters runs in a standalone DIGITAL processor, see the information in this chapter.
- If the forecasting system runs in a DECnet node at corporate headquarters, see Chapter 3, *DECnet* and in Chapter 4, *Communications Servers*, Section 4.3, *The DECnet Router/X.25 Gateway*.

Figure 5-4 shows placement of the remote terminals.

If all or some of the remote locations were geographically proximate, they could conceivably be organized into regions, each of which would furnish the services of a regional node on the PSN for transmission of data to the corporate processor. This approach might be more cost-effective than connecting each terminal to the PSN.

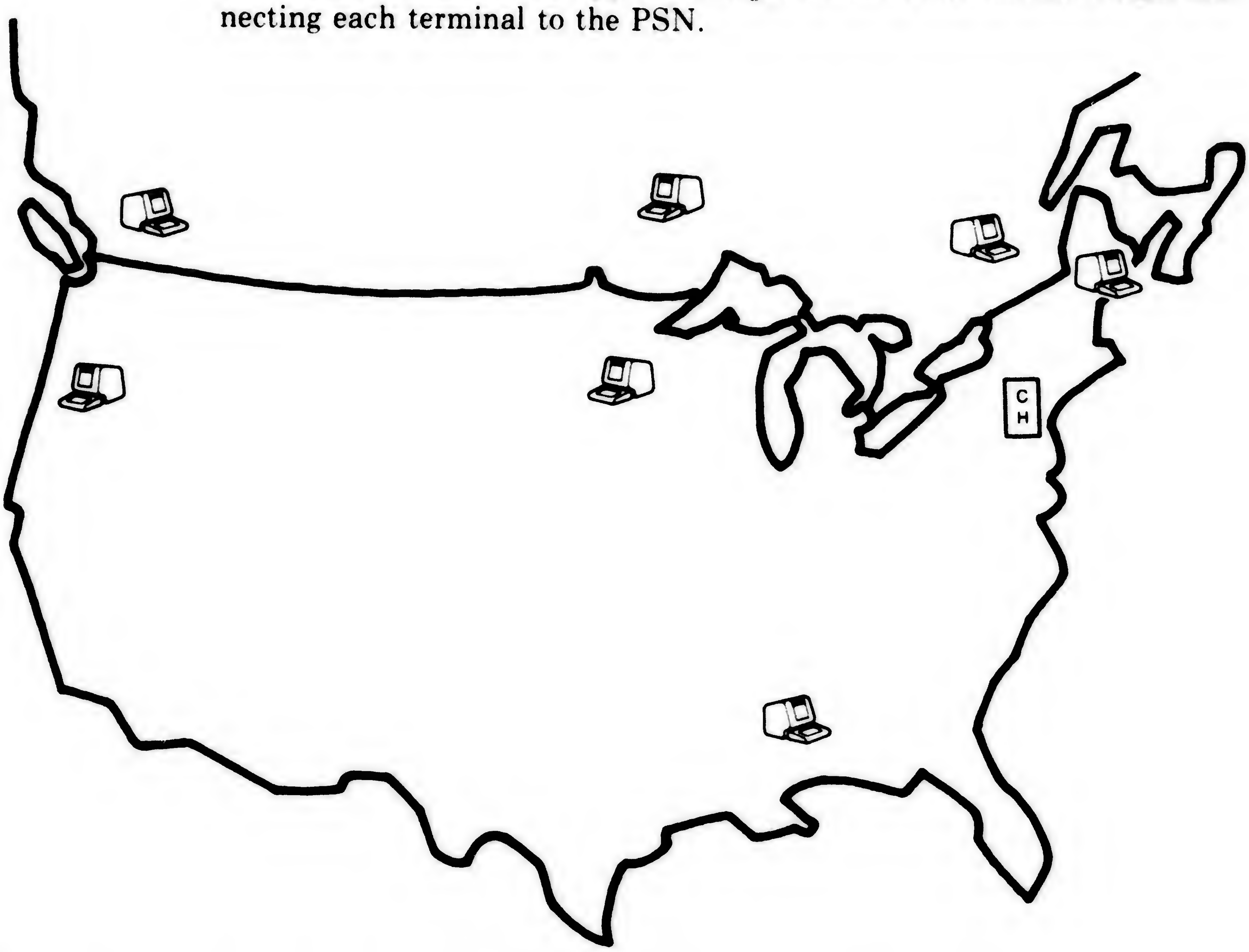


Figure 5-4: Terminals at Remote Locations Transmit over Linked Packet Switching Networks

Chapter 6
DIGITAL's Foreign Protocol-based Products

These DIGITAL Networking Products emulate foreign vendor communications protocols or devices that have become industry standards for certain communications functions. In emulating these protocols, DIGITAL standalone systems take on a communications capability that enables them to participate as dedicated function nodes networked with a nonDIGITAL host system. Even as they operate as nodes in this manner, they continue to function as autonomous processors, providing applications processing and program development support.

The communications protocols emulated by these products are:

- IBM's Binary Synchronous Communications Protocol (BISYNC)
- IBM's Systems Network Architecture (SNA) Protocol

These protocols are emulated for four specific functions:

1. To permit DIGITAL systems to engage in file transfer activities with IBM, CDC, and UNIVAC systems. The products that give DIGITAL systems this capability for communicating with IBM are called 2780/3780 Protocol Emulators (PEs).

   Communication between DIGITAL RSX and IAS systems and CDC systems (CDC-6000 or CDC-CYBER) is effected by means of a DIGITAL product called MUX200. Communication between DIGITAL and UNIVAC 1100 mainframes is effected by means of the DIGITAL UN1004/RSX product. Each of these products appears to be a supported device to the mainframe with which it communicates.

2. To permit DIGITAL systems to be viewed by an IBM host as HASP Remote Job Entry workstations. These products are known as HASP Workstation Protocol Emulators.

3. To permit DIGITAL systems to engage in task-to-task, interactive communications with an IBM host. In addition, terminal emulation enables DIGITAL VT100 terminals to operate as IBM 3277 terminals in communication with an IBM mainframe. These products comprise the 3270 Protocol Emulator product group.
4. To permit RSX systems to engage in task-to-task communications with programs running in an IBM SNA environment. This product is called the RSX/SNA Protocol Emulator.

Each of these products is described in separate sections of this chapter.

6.1 2780/3780 Protocol Emulators

These networking products enable DIGITAL and IBM systems to engage in file transfer activities. The DIGITAL systems are viewed by the IBM mainframe as Remote Batch Job Entry Workstations. While acting in this capacity, the DIGITAL systems continue to function as full-service computers, supporting application processing and program development.

The two processors are connected by dedicated or switched point-to-point lines, with Autoanswer capability supported in some of the 2780/3780 Protocol Emulators (PEs) for the switched line connection.

The IBM Binary Synchronous Communications Protocol (BISYNC) is emulated; functionally, however, the protocol emulator and the IBM 2780/3780 product are significantly different.

The protocol emulator transmits from and receives to tape or disk. In other words, the PE handles remote batch data entry by means of a file system.

Batch streams from IBM are controlled by means of the IBM Job Control Language; the 2780/3780 PE user enters commands if files are being transferred interactively, or invokes indirect command files to control job flow. Use of the indirect command files in an unattended environment enables the 2780/3780 user to build traps to recovery procedures that can either terminate the procedure or trigger other functions. With this ability, you can utilize configuration resources that would otherwise be tied up if an error condition caused a procedure to *hang* while running unattended.

Most importantly, however, the 2780/3780 PEs open a line of communication from DIGITAL to IBM systems dedicated to file transfer operations. By means of these emulators, a functionally dedicated network is established between the communicating processors. DIGITAL systems take on a communications capability, while continuing to fulfill their roles in application processing and program development.

Most of the PEs provide monitoring and troubleshooting facilities. To aid in monitoring operation, the PEs maintain traffic and error counters, and provide status reporting on demand. A loopback testing capability enables you to troubleshoot the communications hardware configuration.

6.2 HASP RJE Workstation Protocol Emulator

This networking product enables a DIGITAL full service computer to communicate with an IBM mainframe that supports IBM's Job Entry Subsystem.

The Protocol Emulator is viewed as a HASP Remote Job Entry Workstation by the IBM processor. While operating in this capacity, exercising job management, data management, and task management functions in a high volume batch environment, the DIGITAL system in which the PE resides continues to provide application processing and program development support.

The PE supports communication for up to seven input and seven output data streams over a point-to-point line connecting it with the IBM mainframe. Multi-leaving of input and output data streams permits concurrent transmission/reception of card images and printed output. The IBM Binary Synchronous Communications Protocol is the line discipline emulated.

Remote console support enables operators on the DIGITAL configuration to communicate directly with the IBM mainframe to check job status and control job flow.

In common with other DIGITAL networking products, the HASP PE offers monitoring functions that provide status reporting and maintain error counters. Loopback testing facilities enable you to check the communications hardware configuration that links the HASP PE to the IBM mainframe.

6.3 3271 Protocol Emulators

These networking products enable applications running in DIGITAL systems to interact with cooperating applications running in host IBM systems that support the IBM 3271 communications protocol. The host IBM system views the 3271 PE as an IBM 3271 control unit.

On a program-to-program basis, the cooperating programs can perform functions such as the following:

- Make inquiries against, and issue updates to, IBM or DIGITAL data bases.
- Transmit/receive files between DIGITAL and IBM systems.
- Transmit and receive screens of data formatted in accordance with IBM's 3270 terminal conventions.

The PE applies and supervises the IBM Binary Synchronous Communications Protocol (BISYNC) over full- or half-duplex data links in either point-to-point or multipoint configurations. It can support multiple synchronous lines and as many as 32 application programs. Figure 6–1 illustrates a configuration that includes both the PE and an IBM 3271.

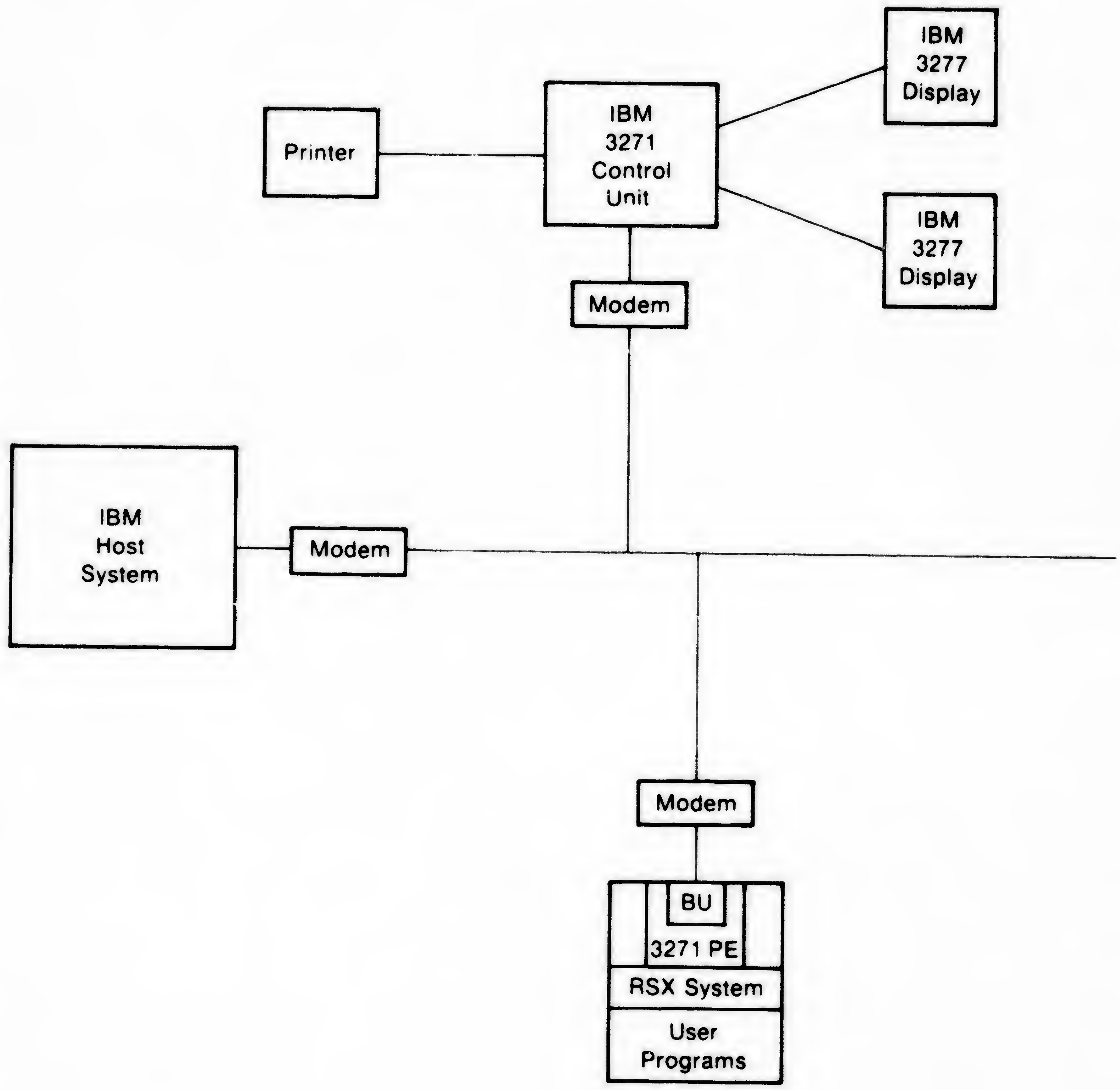


Figure 6–1: A Multidrop Configuration Showing 3271 PE and an IBM 3271 in Communication with IBM Host

VT100 terminals attached to DIGITAL systems are, in effect, transformed by this product into IBM 3270 terminals which can be used to access the IBM system. It also continues to serve the DIGITAL side of the configuration as a VT100 terminal.

If you are looking for identical function in a DECnet to IBM SNA configuration, see Chapter 4.

6.4 RSX/SNA Protocol Emulator

This networking product enables applications in a DIGITAL RSX-11M system to communicate with applications in an IBM mainframe that runs in a configuration designed in accordance with Systems Network Architecture. User-written programs in the DIGITAL and IBM systems interact via the PE as if they were written for and resided in the same environment.

Three operating modes enable you to choose the range of SNA communications protocol you want to exercise. Emulator Control (EC) mode gives you a limited range, as the PE does most of the work in applying SNA-prescribed header information to messages going to IBM, and stripping it from messages coming from IBM. The SNA protocol, in this mode, is virtually transparent to the DIGITAL user. In Extended Emulator Control (XEC) mode, a greater range of the SNA communications protocol is available, but the programs running in the RSX system must manage part of it. In Applications Control (AC) mode, the entire range of SNA communications protocol may be used, but the cooperating programs must manage all of it. In AC mode, the SNA PE is involved only in initiating and ending a session between the cooperating programs.

The SNA PE enables DIGITAL RSX systems, that may be operating as standalone processors, to become active participants in an IBM SNA network. The IBM systems view the SNA PEs as programmable cluster controllers in an SNA network.

For information on how DECnet nodes communicate with IBM SNA on task-to-task and on terminal emulation bases, see Chapter 4.

Application Scenario # 7: ORDER ENTRY/CREDIT CHECK
DIGITAL Terminals Emulate IBM 3271

Communications Problem: How can terminals on a DIGITAL system communicate with an IBM mainframe on a program-to-program, menu/inquiry basis?

Application/Environment Example: This user has one or more DIGITAL systems operating in a standalone capacity. In addition to order entry, each area sales office runs autonomous applications that update customer files. Order histories and customer profiles are compiled, based on the amount and type of equipment purchased by each customer. Names of purchasing agents are updated and results of sales calls are summarized.

The Accounts Receivable Department at corporate headquarters has noted that the number of overdue accounts has increased of late. As a result, it has decided to scrutinize orders and customer histories more closely prior to authorizing order placement. A code, specifying remittance terms, was to be applied based on criteria by which the customer profile would be judged.

So as not to offend customers or delay shipment of orders, the customer/profile information must be made available on line to terminals at the Credit Department. All accounting applications run on an IBM mainframe. A means must be devised for transmitting formatted, transaction-type input from the DIGITAL systems at the area offices to the IBM-based terminals at corporate headquarters. Also, the terminals at corporate must be able to use an inquiry capability against the customer/order files maintained at the sales offices.

The DIGITAL product that can contribute to the solution of this type of problem is the 3271 Protocol Emulator product set, described in Section 6.3. If the same kind of capability is required for a DECnet node in communication with an IBM mainframe in an SNA environment, see Chapter 4.

Communications Problem: How can I move files on a BISYNC line between a DIGITAL system and an IBM mainframe?

Application/Environment Example: A user has one or more DIGITAL systems working either as standalone processors or as DECnet nodes. The systems are located in branch offices, research labs, warehouses, corporate headquarters — every location that has need of autonomous processing capability.

One of the applications running at the warehouses, for example, maintains detailed maintenance/repair/downtime records on its fork lift trucks, accumulating downtime for repair histories on each unit. Thresholds have been established on the basis of which forklifts are taken out of service either for major overhauls or for replacement. On a regular basis, the system also specifies the units to be taken out of service for scheduled maintenance.

The company decides that rather than tying up capital investment by owning and maintaining several groups of forklifts, and supporting the maintenance facilities and crews required, it might be more economical to enter into a lease-service agreement covering all of them on a fleet basis. A study has been instituted to determine feasibility.

To monitor costs, periodic input on downtime and parts replacements is transmitted from each warehouse to a report generator that runs in an IBM mainframe at corporate headquarters. The maintenance data accumulated would help determine the feasibility of a lease-service agreement. The DIGITAL processors at the warehouses were recruited in this effort. In effect, the once autonomous DIGITAL processors became IBM-compatible workstations, while continuing to process jobs that were of purely local interest at the warehouses.

The solution to this kind of problem, as outlined in Section 6.1, enabled the company to institute other warehouse-to-headquarters applications. A centralized inventory control system, for example, now uses input from raw materials storage and production facilities.

Application Scenario #9: ORDER ENTRY AND ORDER PROCESSING
DIGITAL and SNA Applications Interact

Communications Problem: How can I establish program-to-program communication between applications running in remote DIGITAL systems and a centralized application running in an IBM mainframe defined by SNA.

Application/Environment Example: Order entry applications run in standalone systems at a textile manufacturer's regional sales offices. An IBM mainframe at the company's warehouse and distribution center is a host in a corporate-wide network defined by Systems Network Architecture.

One of the applications in the mainframe processes cutting orders, bills of lading, truck assignment and routing based on sales information. Input to this application comes from the customer data base maintained locally at the distribution center and the order information gathered and processed at the remote sales offices.

The DIGITAL networking product that enables the DIGITAL systems to transmit order information to the IBM application, and receive confirmation of order placement and completion back from the IBM application is the DECnet/SNA Gateway. This product is described in Section 4.4. Cooperating programs in the IBM and DIGITAL systems exchange information by means of the Gateway's application interface capability.

Appendix A
The DIGITAL Network Architecture: Summary Description

The DIGITAL Network Architecture (DNA) is the model for all DECnet implementations and the standard that allows different DIGITAL operating systems to participate in the same network. It also permits DECnet nodes to communicate through Gateways and Server nodes with communications facilities and other networks defined by X.25 and SNA protocols.

DNA consists of layers, each of which defines a distinct set of network functions and the rules for performing them. Accordingly, each DECnet implementation consists of software modules that perform these layered network functions as DNA dictates.

A.1 The DNA Layers

Figure A-1 illustrates the DNA functional layers. The following definitions summarize the purpose of each layer.

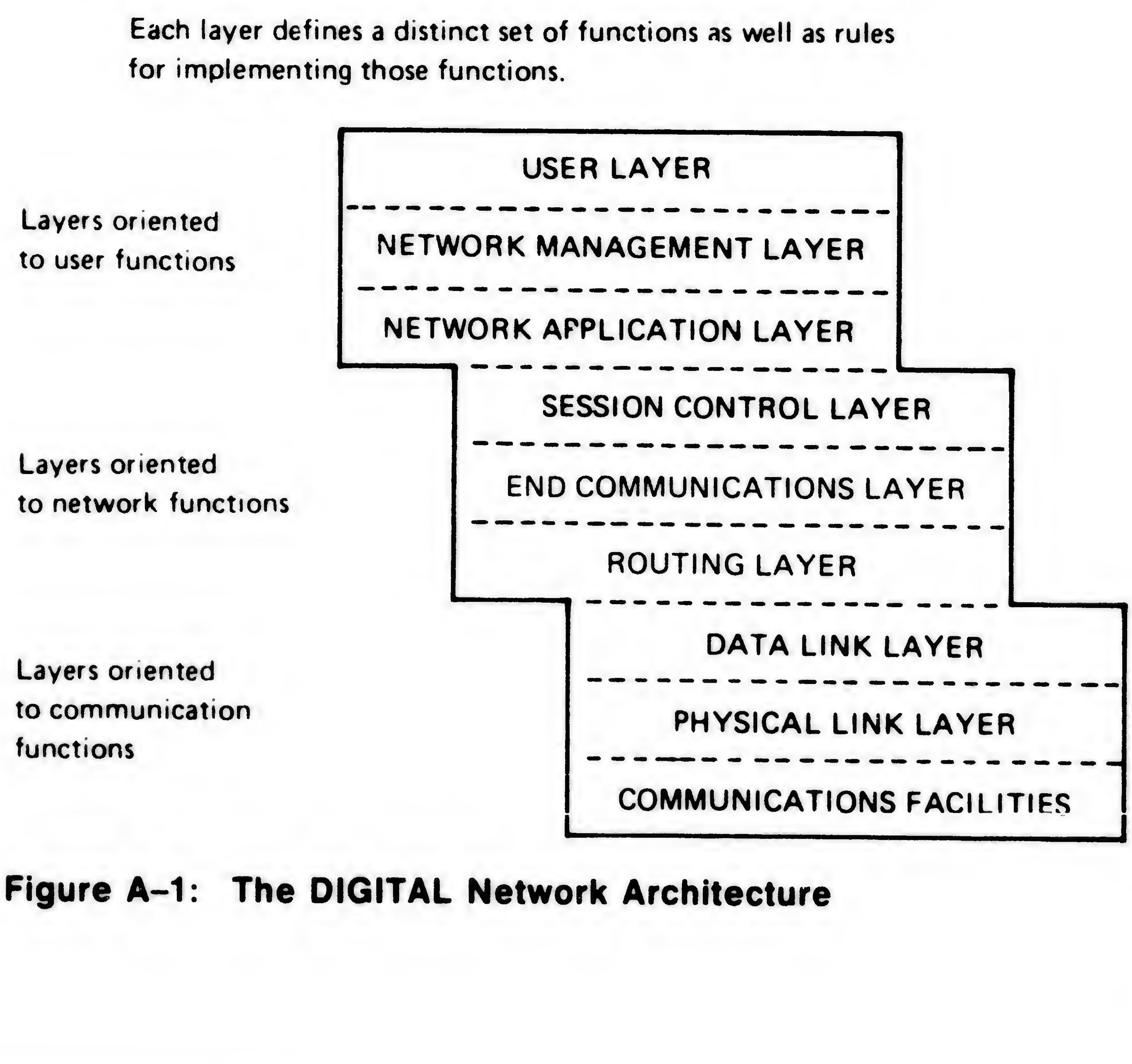


Figure A-1: The DIGITAL Network Architecture

- **User Layer.** This layer encompasses user-written programs and services that access the network.
- **Network Management Layer.** This layer defines the functions used by operators and programs to plan, control, and maintain the operation of DECnet networks.
- **Network Application Layer.** This layer defines network functions used by the two higher layers. The most important DECnet functions currently operating in this layer are: Remote File Access, File Transfer, the Remote Terminal Capability, and access to X.25 and SNA Gateways.
- **Session Control Layer.** This layer defines a mechanism that allows a program in one node to communicate with a program in another node, regardless of either program's location in the network. Modules in the User Layer, the Network Management Layer, and the Network Application Layer, can use the mechanism provided by the Session Control Layer. This mechanism is called the logical link.
- **End Communication Layer.** This layer handles the system independent aspects of logical link communications. These include connection management, data flow control, end-to-end error control, and segmentation/reassembly of user messages.
- **Routing Layer.** This layer defines the mechanism for routing user data from a source to a destination node. Modules in this layer also provide congestion control and packet lifetime control.
- **Data Link Layer.** This layer defines a mechanism for error-free communication between adjacent nodes, between a node and an X.25 network, and between a node and an Ethernet LAN.
- **Physical Link Layer.** This layer encompasses the software device driver for each communications device, plus the communications hardware itself. The hardware includes interface devices, modems, and the communications lines.

A.2 DECnet Module Interfaces

DNA defines the interfaces between DECnet software modules operating within the same node. Reflecting the structure of DNA, each module can communicate with modules in a higher or a lower layer, but not with another module in the same layer. Using these vertical interfaces, each module uses the services provided by a module in a lower layer (see Figure A-2). In building-block fashion, the modules in each layer support higher level modules by providing them with required network services.

Figure A-2 illustrates a collection of modules residing in a typical DECnet mode. The arrows represent the interfaces between modules. The arrows point down because each module uses the services provided by a module in a lower layer; a module cannot use services provided by a higher level module.

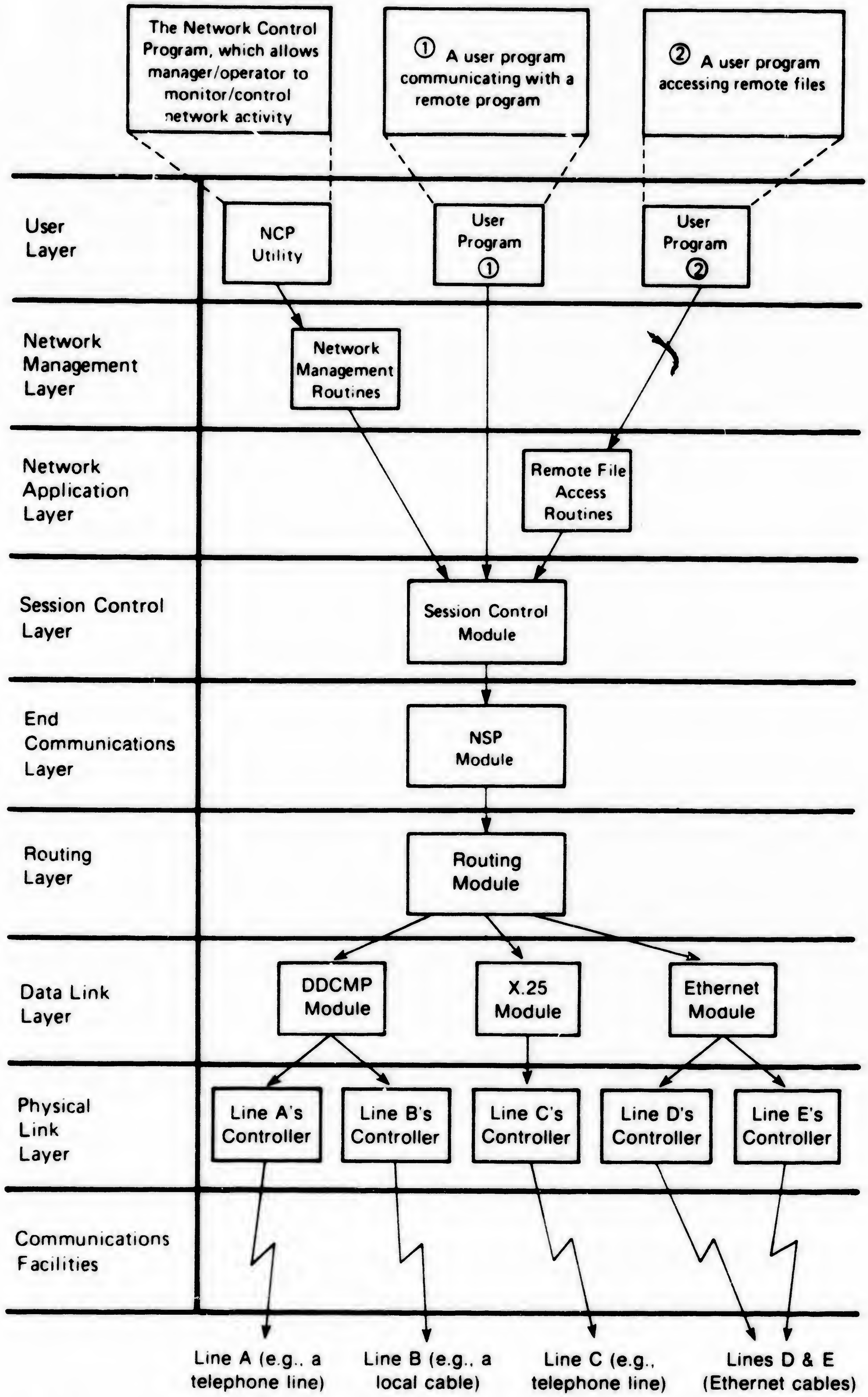


Figure A-2: DNA Modules Resident in a Typical DECnet Node

A.3 DNA Protocols

In addition to defining vertical interfaces within a node, DNA also defines the relationships between modules in separate nodes. A module in one node communicates only with an equivalent module in another node, where *equivalent* means resident in the same layer, and serving the same network function.

Communication between equivalent modules is governed by a set of rules called a protocol. Each protocol defines the form and content of messages to be exchanged by modules residing in the same layer, but in separate nodes. Equivalent modules use the same protocol.

Protocols for modules in the higher layers are more complex than protocols for lower layers. For example, a Physical Link Layer protocol is defined in terms of electrical signals; whereas a protocol for modules residing in the Network Application Layer defines message formats and rules for exchanging messages.

Figure A-3 illustrates protocol communication between equivalent modules in separate nodes. Table A-1 lists and briefly describes the function of each DNA protocol. It also specifies the architectural layer in which each of the protocols reside.

DNA does not define protocols for all functional layers. For example, the User Layer programs communicate over the network according to rules defined by the programmer. Furthermore, more than one protocol can be defined for the same layer because some layers support more than one function. See, for example, the Data Link Layer in Figure A-2. Also, the Network Application Layer can include modules that use the Data Access Protocol (DAP), as well as modules that use a protocol defined by users for a specific network application (transaction processing, for example). The protocols that DNA does define are also not exclusive; users can substitute their own protocols, as long as they are implemented consistently by equivalent modules throughout the network.

For detailed information on DNA and each of the protocols it defines, see the DNA specifications listed in the Bibliography.

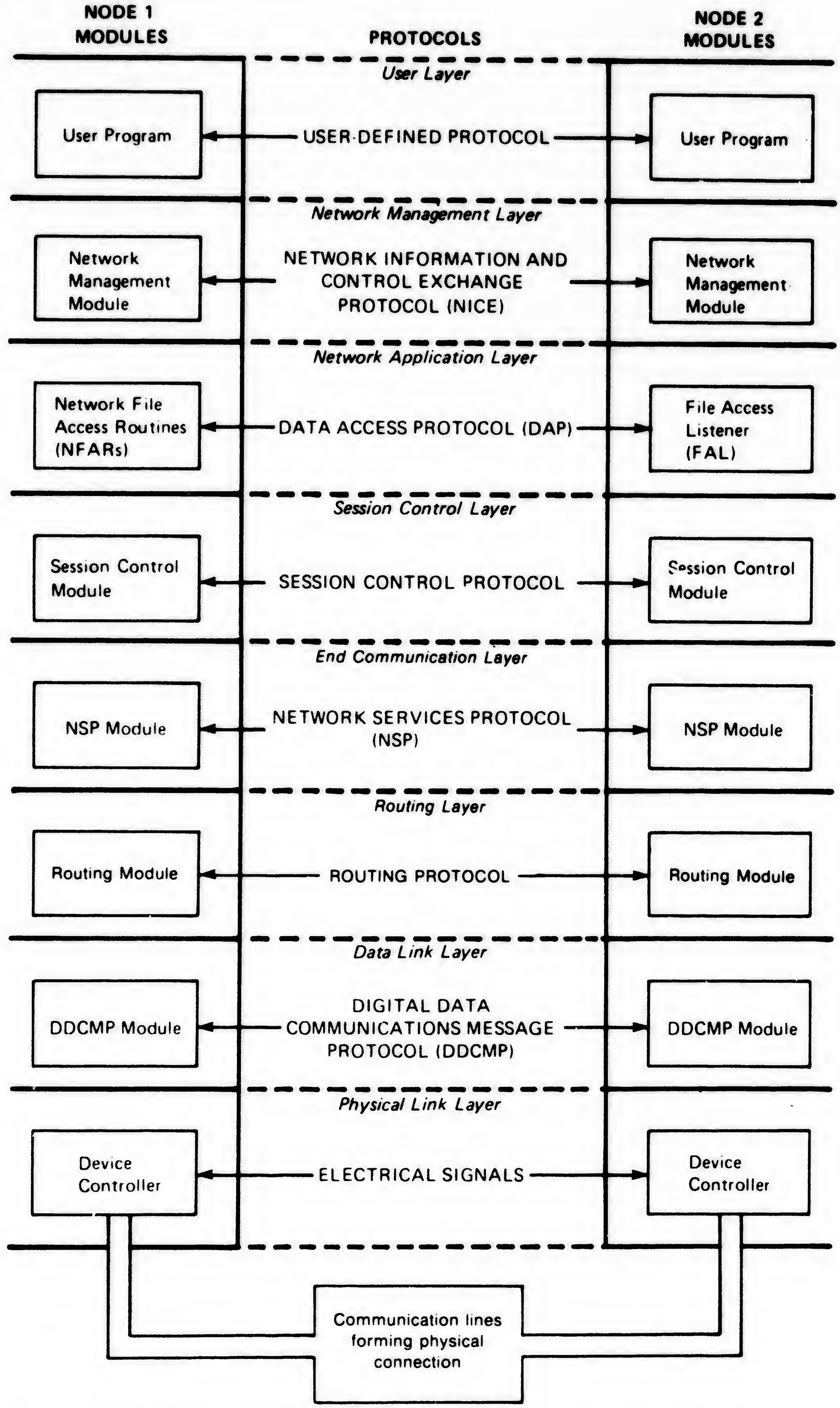


Figure A-3: Protocol Communication Between Two Nodes

Table A-1: DNA Protocols

Protocol	Layer	Description
NICE	Network Management	The Network Information and Control Exchange protocol defines mechanisms for exchanging network, node, and configuration data, and for servicing requests from modules residing in the Network Management Layer.
Event Logger	Network Management	The Event Logger Protocol records significant events that occur in the lower layers of the architecture. Significant events include: line up, counter reaching threshold, node becoming unreachable, etc.
DAP	Network Application	The Data Access Protocol defines mechanisms for performing remote file access and remote file transfer on behalf of software modules residing in the Network Management Layer and the User Layer.
Network Virtual Terminal Protocols	Network Application	This is a family of protocols used for terminal access through the network.
X.25 Gateway Access Protocol	Network Application	This protocol allows a node that is not connected directly with a PSN to access the facilities of that network through an intermediary Gateway node.
SNA Gateway Access Protocol	Network Application	This protocol allows a node which is not connected directly to an IBM SNA network, access to SNA facilities for terminal access and remote job entry.
Loopback Mirror Protocol	Network Application	This protocol is used for network management logical link loopback tests.
Session Control	Session Control	The Session Control Protocol sends and receives logical link data, and disconnects and aborts logical links. Functions include: mapping node names to node addresses, identifying end users, activating or creating processes, and validating incoming connect requests.
Network Services Protocol	End Communications	The Network Services Protocol defines a mechanism for creating and maintaining logical links between higher level modules residing in the same node or in different nodes.
Routing	Routing	The Routing Protocol defines a mechanism for dispatching data to any node in the network.
MOP	Data Link	The Maintenance Operation Protocol defines mechanisms for transmitting data over a communications channel to perform specific functions such as: down-line loading of a remote node; up-line dumping from a remote node; testing a node and network connections; and starting up an unattended remote node.

(continued on next page)

Table A-1 (Cont.): DNA Protocols

Protocol	Layer	Description
DDCMP	Data Link	The Digital Data Communications Message Protocol defines a mechanism for ensuring the integrity and sequentiality of data transmitted over a synchronous, asynchronous, or parallel communications channel.
X.25	Data Link	The X.25 Protocol defines a standard interface between Data Terminal Equipment, such as DECnet nodes, and a packet-switched data network.
Ethernet	Data Link	The Ethernet Protocol provides a best-effort delivery service between a Phase IV DECnet node and the Ethernet local area network. It also provides link management procedures and an error detection capability.

Appendix B
DECnet: A Short History

DECnet is Digital Equipment Corporation's designation for its software modules, protocols, hardware, and support services that facilitate construction of distributed processing systems using DIGITAL and nonDIGITAL computers. DECnet had its beginnings during the early 1970's in three parallel efforts to develop network-related capabilities for multiprocessing, for communications, and for remote access to computer resources. To address the challenge of distributed processing, these efforts were joined in a corporate network development program.

The program foresaw an ongoing and orderly development effort consisting of several phases. Each phase would implement proven technologies in a manner consistent with an architected design. Products introduced with each phase would provide new or improved networking features, while retaining compatibility with products developed in preceding phases.

In this way, a product development strategy employed by DIGITAL translated into a network development strategy for its customers.

In 1975, DIGITAL first made public its intention to design and market inexpensive and practical networks of distributed systems. The announcement was supported by the introduction of the Digital Network Architecture (DNA), a system of layered protocols that establish links and govern data transmission between computer systems. The following year brought the first release of DECnet software products, which provided basic user and communication capability (program-to-program, point-to-point) for links between real-time systems of the PDP-11 family. Phase I of DECnet proved the validity of Digital's networking concepts and resulted in the installation of approximately 900 operational network nodes.

In 1978, a second phase of DECnet products was announced, extending network capability across all major real-time, timesharing, and multifunction DIGITAL operating systems. At the same time, user capability was taken beyond the byte-oriented data exchange of Phase I to include copying and transfer of data files from remote systems upon user command. Real-time PDP-11 and VAX systems could also engage in remote resource access, which includes the capability for users at one network node to open, read, write, and close data files residing in mass storage at another node.

Along with these were capabilities for remote batch and command file submission and initial network management routines. Phase II also saw the continued development of high-quality product testing and support services, which improved customer satisfaction.

DECnet Phase III concentrated on extending the communication capability among Digital's computers to include message routing, multipoint communication and network command terminals, thereby expanding fourfold the matrix of user and communication functions available to DECnet users.

DECnet Phase IV establishes DIGITAL as a major supplier of products for multi-vendor network environments.

Terminals and processors using communication devices and techniques implemented in this Phase enable DECnet nodes to interact with one another and with nonDECnet systems over local and wide-area networks, over public data networks using X.25 protocols, and with IBM SNA mainframes.

With communications server products acting as network front-ends, Phase IV responds to user needs for larger networks, flexible layout, and for cost-effective use of computers as applications processors.

The latest stage in an effort begun in 1975 contributes a set of products that fosters an orderly extension of networking capability while protecting customer investment in existing networking equipment.

Glossary

This glossary defines terms as used in this Overview.

adjacent node

An adjacent node is a node removed from the local node by a single physical line.

asynchronous transmission

Transmission in which time intervals between transmitted characters may be of unequal length. Transmission is controlled by start and stop elements at the beginning and end of each character.

binary synchronous protocol

A data link protocol that uses a defined set of control characters and control character sequences for synchronized transmission of binary coded data between stations in a data communications system.

carrier-sense multiple access with collision detection (CSMA/CD)

A distributed channel allocation procedure in which every station can receive all other stations' transmissions. Each station awaits an idle channel before transmitting, and each station can detect overlapping transmissions by other stations.

CCITT

See Comite Consultatif Internationale Telephonique et Telegraphique.

circuit

A logical connection between protocol modules at the Data Link Layer. There is one circuit for each DDCMP point-to-point line and one circuit for each tributary station on a DDCMP multi-point line. There is one circuit for each X.25 permanent or switched virtual circuit. There is one circuit for each protocol type on an Ethernet.

coaxial cable

A low noise, heat resistant, shielded PVC or TEFLON-type, 50-ohm coaxial cable, which serves as the passive communications medium used to link devices together into a local Ethernet Network.

Comite Consultatif Internationale Telephonique et Telegraphique (CCITT)

An international committee that sets communications usage standards.

communications servers

Phase IV nodes that act as network front ends in off-loading certain communications functions from host nodes. communications servers consist of Router Servers, Terminal Servers, and Gateway nodes.

CSMA/CD

See carrier-sense multiple access with collision detection.

device

Any data handling or user equipment connected to the network.

dial-up line

A communications circuit that is established by a switched circuit connection.

down-line load

The process by which one node in a computer network transfers an entire system image or a program (task) image to another node and causes it to be executed.

Ethernet

A communications concept for local communication networks that employ coaxial cable as a passive communications medium to interconnect different kinds of computers, information processing products, and office equipment at a local business site, without requiring switching logic or control by a central computer.

event

An event is a network or system-specific occurrence for which the logging component maintains a record.

fiber optic cable

A transmission medium designed to transmit digital signals in the form of pulses of light. Fiber optic cable is noted for its properties of electrical isolation and resistance to electrostatic contamination.

flow control

The protocol mechanism that ensures that the sending station does not overrun the receiving station with more data than it can accept.

front-end processor

A communications computer associated with a host computer. It may perform line control, message handling, code conversion, error control and applications functions such as control and operation of special-purpose terminals.

Gateway

A module or set of modules which transforms the conventions or protocols of one network into the conventions or protocols of another.

hierarchical network

A computer network in which processing control functions are performed at several levels by computers specially suited for the functions performed, for example, in a factory or in laboratory automation.

host (host node)

A node primarily devoted to applications processing, but which can also provide services such as down-line load to a target node, or a route-through capability to an adjacent end-node.

interactive communication

A protocol that allows one system to interact with a connected system at the transaction level, rather than at the file level.

interface

1. A shared boundary defined by common physical interconnection characteristics and meanings of interchanger signals.

2. A device or equipment making possible interoperation between two systems, e.g., a hardware component or a common storage register.

3. A shared logical boundary between two software components.

ISO reference model

The International Standards Organization Reference Model for Open System Interconnection, ISO draft proposal DP7498. A proposed international standard for network architectures which defines a seven layer model, specifying services and protocols for each layer.

lan

See local area network.

leased-line

A line reserved for the exclusive use of a leasing customer without interexchange switching arrangements. Also called a private line.

line

The network management component that provides a distinct physical data path.

link

1. Any specific relationship between two nodes in a network.
2. A communications path between two nodes.
3. A data link. See also *line*.

local area network (lan)

A privately owned data communications system that offers high-speed communications channels optimized for connecting information processing equipment. The geographical area is usually limited to a section of a building, an entire building or a group of buildings.

local node

A frame of reference; the node at which the user is physically located. Compare *remote node*.

logical link

A logical link is a carrier of a single stream of full-duplex traffic between two user-level processes.

message

The unit of communication as seen by the user; it may be segmented into several packets to traverse the network, or, in some circumstances, several messages can be carried in one packet.

multipoint connection

A network configuration in which more than two computers are attached to the same line. Use of this type of line normally requires some kind of polling mechanism, addressing each terminal with a unique ID. Also called multidrop. Compare *point-to-point connection*.

network

A configuration of two or more computers linked to share information and resources. A computer having the capacity to participate in a network is called a node.

node

A node is a network management component consisting of a computer system that supports networking software; for instance, a system that supports DECnet software.

non-routing (end) node

A non-routing node can send packets to other nodes in the network, but packets cannot be forwarded or routed through it. It can be adjacent to one other node only; therefore, it is always an end-node in a Phase III configuration.

operating system

An integrated collection of service routines for supervising the sequencing and processing of programs by a computer. An operating system provides access to the capabilities of a central processor, and also organizes and optimizes a central processor and peripheral equipment for a certain range of applications.

packet

A unit of data to be routed from a source node to a destination node. When stripped of its route header and passed to the End Communication Layer, it becomes a datagram.

packet switching network (PSN)

A network in which data to be transmitted is divided into independent and standard-format units of data called packets. Formats and procedures used by Public Packet Switching Networks are governed by X.25 protocol.

permanent virtual circuit

A virtual circuit between two X.25 computers or terminals and computers that is always established. A logical channel is permanently allocated to a permanent virtual circuit at each interface with the PSN.

Phase III node

A DECnet node that runs a Phase III implementation of DECnet and supports routing as either a full routing or non-routing (end) node.

Phase IV node

A DECnet node that runs the Phase IV implementation of DECnet. Phase IV nodes can connect with local area network cables.

point-to-point

A network configuration in which a connection is established between two and only two computers. Compare *multipoint connection.*

protocol

A basic procedure or set of rules that govern and control the flow of messages between computers; also, a set of conventions between communicating processes regarding the format and content of messages to be exchanged. Digital Network Architecture (DNA) uses three basic protocols in a layered structure as the framework for DECnet.

PSN

See packet switching network.

remote node

A frame of reference; any node other than the one at which the user is located in the network. Compare *local node.*

Router Server

A Phase IV DECnet node that performs routing functions only. The Router Server connects with the local area network cable on one side and with host nodes or other communications servers on the other.

route-through

The process of directing packets from source nodes to destination nodes by one or more intermediary nodes. Routing nodes permit route-through. Also called packet switching.

routing

The process of directing data message packets from source nodes to destination nodes.

routing node

A full routing node can forward packets to other nodes in the network and can be adjacent to all other types of nodes.

SNA

System Network Architecture. A methodology for networking IBM computers with each other.

switched line

A communications link for which the physical path may vary with each usage, e.g., the dial-up telephone network.

switched virtual circuit

A temporary association between nodes and/or terminals on a PSN.

synchronous transmission

Transmission in which the data characters and bits are transmitted at a fixed rate with the transmitter and receiver synchronized. This eliminates the need for start-stop elements, thus providing greater efficiency. Compare *Asynchronous Transmission*.

Terminal Server

A Phase IV DECnet node that connects up to 32 terminals with the network.

topology

The physical or logical placement of nodes in a computer network.

transceiver

The device that connects directly to the coaxial cable to provide both the electronics to send and receive the encoded signals and to detect *collisions* or *clear channel* on the cable and the required electrical isolation. It is the coupling device that links the user device to the coaxial cable.

unattended operation

The automatic features of a node's operation that permit the transmission and reception of messages on an unattended basis.

up-line dump

To send a copy of a target node's memory image up a line to a file at the host node.

virtual terminal

A terminal physically connected to a host node or Terminal Server that can logically connect with another node.

wide-area network

A public or private data communications system in which transmissions are carried primarily over telephone lines.

X.25

A communications protocol for Public Packet Switching Networks.

X.25 Gateway

A Phase IV DECnet node that connects nodes in the DECnet network to DECnet nodes or to nonDECnet nodes on a Packet Switching Network that uses the X.25 protocol.

Bibliography

This bibliography lists the titles of technical manuals that provide specific information on the DIGITAL Network Architecture, and on many of the DIGITAL Networking Products discussed in this manual.

DIGITAL Network Architecture

General Description (Phase IV)

Data Access Protocol (DAP) Functional Specification

Digital Data Communication Message Protocol (DDCMP) Functional Specification

Routing Functional Specification (Phase IV)

Maintenance Operations Functional Specification (Phase IV)

Network Management Functional Specification (Phase IV)

End Communications Functional Specification (Phase IV)

DIGITAL Networking Products

General

Overview of DIGITAL Networking Products

Communications Server Products:

DECnet Router

DECnet Router Installation and Operation Guide

DECnet Router/X.25 Gateway

Introduction to PSI (VAX or RSX)

DECnet Router /X.25 Gateway Installation and Operation Manual

Network Specific Information Reference Cards

DECnet Router/X.25 Gateway Release Notes

DECnet/SNA Gateway: General

DECnet/SNA Gateway Introduction

DECnet/SNA Gateway Installation Guide

DECnet/SNA Gateway Problem Determination Guide

DECnet/SNA Gateway IBM Parameters

DECnet/SNA Gateway Release Notes

DECnet/SNA Gateway VMS

DECnet/SNA VMS Gateway Management Guide

DECnet/SNA VMS 3270 Terminal Emulator User's Guide

DECnet/SNA VMS Gateway Remote Job Entry User's and Operator's Guide

DECnet/SNA VMS Gateway Application Interface Programmer's Guide

DECnet/SNA Gateway RSX

DECnet/SNA RSX Gateway Management Guide

DECnet/SNA RSX 3270 Terminal Emulator User's Guide

DECnet/SNA RSX Remote Job Entry User's and Operator's Guide

DECnet/SNA RSX Application Interface Programmer's Guide

Terminal Server

Terminal Server Installation and Operation Manual

Terminal Server User's Pocket Reference Guide

DECnet Products

General

Introduction to DECnet

DECnet-VAX

DECnet-VAX System Manager's Guide

DECnet-VAX User's Guide

DECnet-VAX Key Installation Guide

DECnet-VAX Cross System Notes

PRO/DECnet

User's Guide

PRO/DECnet Programmer's Reference Manual

DECnet-RSX

Overview of RSX-DECnet

DECnet-RSX System Manager's Guide

DECnet-RSX Network Generation and Installation Manual

DECnet-RSX Post Installation Checkout Procedures

DECnet-RSX Guide to User Utilities

DECnet-RSX Programmer's Reference Manual

DECnet-RSX Release Notes

DECnet-20

DECnet-20 User's Guide

DECnet-20 System Manager's and Operator's Guide

DECnet-20 Network Generation and Installation Procedures

DECnet-10

DECnet-10 User's Guide

DECnet-10 System Manager's and Operator's Guide

DECnet-10 Network Generation and Installation Procedures

DECnet/E

DECnet/E System Manager's Guide

DECnet/E Network Installation Procedures

DECnet/E Guide to User Utilities

DECnet/E Network Programming in BASIC

DECnet/E Network Programming in COBOL

DECnet/E Network Programming in FORTRAN

DECnet/E Network Programming in MACRO

DECnet/E Release Notes

DECnet-RT

DECnet-RT Documentation Directory

DECnet-RT System Manager's Guide

DECnet-RT Network Generation and Installation Guide

DECnet-RT Guide to User Utilities

DECnet-RT Programmer's Reference Manual

DECnet-RT Unsupported Software

DECnet-RT Release Notes

Ethernet Products

Introduction to Local Area Networks

DIGITAL Ethernet Products and Services

The Ethernet

Ethernet Installation Guide

H4000 Transceiver Technical Manual

H4000 Installation Manual

DEUNA Technical Description

DECSA Site Preparation Guide

DECSA Technical Description

DECSA Installation Guide

DECSA Operator's Guide

DELNI Installation Manual

Repeater Technical Manual

Repeater Installation Manual

Packetnet Switch Interface Products

VAX-11

Introduction to VAX-11 PSI

X.25 Programmer's Guide

VAX-11 PSI Guide to Using X.29

VAX-11 PSI Guide to Using X.29: Update 1

VAX-11 PSI Installation Procedures

Network Specific Information Reference Cards

Host-Based PAD Reference Card

VAX-11 PSI Release Notes

Installing/Managing the X.25/X.29 Extension Package

X.25/X.29 Extension Package Release Notes

RSX-11

Introduction to RSX-11 PSI

RSX-11 PSI User's Guide

RSX-11 PSI System Manager's Guide

Network Specific Information

RSX-11 PSI Generation Guide

RSX-11 PSI Reference Card

RSX-11 PSI Release Notes

Protocol Emulator Products

2780/3780 Protocol Emulators

IAS 2780 System Operator's Guide

IAS 2780 Release Notes

RSTS/E 2780 Remote Computer System Installation Notes

CTS-500 System Generation Using Diskettes

RSTS/E 2780 User's Guide

RSX-11 2780/3780 User's Guide

RT-11 2780/3780 Installation and User's Guide

RT-11 2780/3780 Release Notes

VAX-11 2780/3780 User's Guide

VAX-11 2780/3780 Release Notes

TOPS-20 IBM 2780/3780/HASP Terminal Emulation

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IAS 3271 System Manager's Guide

RSTS/E

RSTS/E 3271 User's Guide

RSTS/E 3271 Release Notes

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RSX-11 3271 System Manager's Guide

RSX-11 3271 Release Notes

3270 TT Emulator Keyboard Layout

RSX-11M-PLUS

RSX-11M-PLUS 3271 Programmer's Guide

RSX-11M-PLUS 3271 System Manager's Guide

RSX-11M-PLUS 3271 Release Notes

3270 TT Emulator Keyboard Layout

VAX

VAX-11 3271 User's Guide

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HASP Workstation Installation Guide

HASP Workstation Operator's Guide

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System Manager's Guide

Application Programmer's Guide

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